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SCHOOL PLANT AND EQUIPMENT

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School Plant and Equipment

Reviews the literature for the three years ending December 1947. Earlier literature was reviewed in Volume II, No. 5; Volume V, No. 4; Volume VIII, No. 4; Volume XII, No. 2; and Volume XV, No. 1.

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The Curriculum: Learning and Teaching

Reviews the literature for the three-year period since the issuance of Volume XV, No. 3, June 1945. Earlier research related to this topic was reviewed in Volume 1, No. 1; Volume 4, No. 2; Volume 7, No. 2; Volume 12, No. 3; and Volume 15, No. 3.

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The Natural Sciences and Mathematics

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Vol. XVIII, No. 6—Special Edition **December 1948**

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FOREWORD

Two years ago the Editorial Board debated at length whether to include in the current cycle a review of research on the school plant. A casual survey of the literature indicated that research in this field had all but ceased. However, even tho the volume of research was dangerously near the vanishing point, the backlog of new school-building construction needed was mounting beyond anything previously faced in American schools and colleges. The decision, as this issue attests, was to maintain the series. The emphasis of this number is not as much on research accomplished, altho that is considerable, as on research needed. Here is a fertile field for those who will shape the new housing of American education.

Unfortunately the committee originally appointed to prepare this issue was unable to carry thru its assignment. At the last minute the committee was reorganized and Dr. Essex accepted the chairmanship. He was ably assisted by members of his staff. To the chairman, the members of his committee, and to the others who have contributed under pressure to preparing this issue, the Editorial Board is greatly indebted.

J. Cayce Morrison, *Editor*

INTRODUCTION

THIS is the sixth number of the REVIEW OF EDUCATIONAL RESEARCH dealing with the school plant. It covers the period from August 1, 1944, to December 31, 1947.

The committee has departed somewhat from the topic organization of the previous numbers. Needed research has previously been discussed at the end of each chapter. In this volume the first chapter is devoted exclusively to this subject. Because of widespread interest in recent years in planning the elementary classroom and in designing the school building for community use, chapters on these topics are introduced. There is no chapter on equipment. Other variations from the previous topic organization will be noted.

The committee recognizes that many of the references quoted do not represent research even in a broad sense of the term. This fact does not detract from the value of the volume as the school administrator or the school-building specialist will attest when he turns its pages for suggestions on various phases of school-building planning.

The past three years have seen an unprecedented amount of school-building planning. Members of the committee are all actively and busily engaged in some aspect of this work. That they have been willing to take time from their regular duties and in many cases to work extra hours in order to participate in the preparation of this volume is an indication of their devotion to their chosen field of work.

DON L. ESSEX, *Chairman*
Committee on School Plant and Equipment

CHAPTER I

Needed Research in the School-Plant Field

RAY L. HAMON

THE lack of scientific research and controlled experimentation in the area of school-plant facilities is appalling when considered in the light of a pending ten-billion-dollar plant program. Altho many factors have been partially determined by research and by expensive trial and error, there is an ever-growing need for additional research to determine desirable facilities for expanding educational programs and the best practices in the application of new materials and technics to educational housing.

Many materials, technics, and practices in the general fields of architecture, landscape design, construction, and furnishings are equally applicable to school plants. It is not necessary, therefore, that every feature of the school plant be a specific research subject. We can borrow many results of research from the general building field. In addition to general building features which are transferable to school plants, many aspects of general construction could be adapted to school use. Unfortunately, however, the entire building industry has been slow to apply scientific research methods to its problems. Research and progress in the building industry have not kept pace with the fields of medicine, transportation, and communication.

Even if adequate research results were available in regard to general specifications, engineering designs, and construction practices, and if such results were applicable to schools, there would remain thousands of unanswered questions as to space planning and plant tailoring to fit modern educational requirements.

During past years many suggested lists of school-plant research subjects have been published. Four are given here in their chronological order. Holy (3, 4), in two previous issues of REVIEW OF EDUCATIONAL RESEARCH, contrasted the lack of school-plant research with extensive research in other fields, and listed several phases of the school plant which need further research. The School Plant Research Committee of the American Council on Education (1) devoted a thirty-page study to the status of and the need for school-plant research. Brainard (2) pointed out the need for further research in the school-plant field, discussed some examples of specific research subjects, and proposed a program of action.

There has been some research on some of the subjects listed in the foregoing references. Many of the previously listed subjects are relisted herein, because there is still need for further and more fundamental research in these areas. The following listing is by no means complete, but the subjects are examples of some of the more important phases of the school-plant area in which immediate research is needed.

Acoustics

Sound control has become an important problem in schools, because of more informal school procedures and a greater use of nonsound-absorbent building materials. There are many acoustical materials available for many purposes. Research is needed to determine the amount of sound control necessary for various areas of the school building, and the types and amounts of materials required for satisfactory results in different areas. Some of the problems not yet satisfactorily solved are: (a) low-cost, fire-resistive acoustical material which will not require mounting on a fire-resistive base, (b) better means of mounting so the tile will not come off, (c) material which will not discolor with age, (d) repainting without loss of acoustical efficiency, and (e) a moisture-resistant acoustical material for swimming pool ceilings.

Codes

The effects of recently developed materials and designs upon the cost of construction should be carefully analyzed. There are, no doubt, increased costs entailed by following building codes which are in many cases obsolete. Some of this added cost for code compliance may be to protect entrenched interests rather than to protect lives and functional requirements. There is need for research as to design and materials that will reduce construction cost without impairing the functional value of the building or reducing the safety factor. Building codes and regulations should be carefully studied in relation to their present justification and their effect on building progress and costs.

Community Needs

The trend toward greater community use of the school plant is likely to continue. Community use of the school plant will vary according to the type of community and its needs and the availability of other community facilities. The area may be divided into several sections such as: (a) what are the present and future community activities for which physical facilities will be required, (b) which of these community activities should be accommodated in the school plants, (c) what types of community activities should be provided for in different types of schools, (d) determination of functional space and facilities for community needs to be met, (e) methods of planning facilities which will serve both school and community requirements, and (f) plant management problems when facilities are used by different agencies.

Financing the Plant

Research is needed to determine the relative merits of various methods of financing the construction of school buildings. More extensive samples should be used in projecting the division of costs among the different types of building contracts and in setting up the over-all budget for financing a program of capital improvements, with breakdown guides as to relative costs of grounds, structures, and furnishings.

A careful study should be made of the apparent relative effectiveness of the various procedures and devices employed in campaigns for financial support. The results of such a study might be set forth in a campaign manual.

Functional Layouts

The first and most important factors to be considered in planning a school plant are the space requirements of the various areas and their relationships to each other. Areas cannot be determined until functional layouts have been made of each area, and the total plan cannot be developed without considering the affinities of the various areas of the building. These factors require the determination of room locations and dimensions. The architect cannot prepare even sketches until those responsible for educational planning have made these determinations. This is the weakest link in school-plant planning, because satisfactory procedures have not been developed for determining space dimensions and relationships. The situation is the result of the dynamic nature of education, and cannot be fully and permanently overcome. Research and careful analysis of educational programs and trends, however, should result in layouts which will be functional for a generation with but few alterations.

Some of the specific functional layouts for which research is needed are: (a) size and plan of elementary classrooms, (b) kindergartens, (c) facilities for separate primary units, (d) space for music and dramatics, (e) rooms for the teaching of core units in the secondary school, (f) recreational and dressing facilities for all pupils, (g) parents' room, (h) units for joint school and community use, (i) special community facilities, (j) provision for audio-visual aids, (k) shops for trades and industries, (l) space for general arts, (m) counseling and student activity rooms, (n) health facilities, and (o) administrative facilities for teachers, staff, and custodians.

There is need for further study as to plant flexibility for multiple use and future adaptations to changing requirements.

Furniture and Equipment

The chief need for study is related to the types, designs, and sizes of furniture and built-in equipment which will function effectively as educational tools in the various spaces of the school plant. Manufacturers have made some rather good guesses as to functional designs of furniture, with but little help from educators as to the functional needs and educational requirements of furniture for classrooms, laboratories, shops, and the many special and general areas of a school plant. Following are a few of the problems which have not yet been satisfactorily solved: (a) adequate and convenient space for books, supplies, and cloaks; (b) picture projection equipment that can be moved and set up more easily and does not require darkening the room; (c) simplified practice of science furniture types to encourage the economy of pre-order manufacture; (d) multi-use equipment which will increase utilization and reduce over-all costs; (e) light-weight furniture which can be more easily moved by children; and (f) types of equipment needed in the various vocational areas.

Posture should be restudied to determine if present designs and sizes of furniture are satisfactory. There should be further research on lighter finishes of furniture, equipment, cases, and lockers so all manufacturers can establish their base prices on a generally accepted light finish. There is also need for further research on performance-test specifications to improve procedures in purchasing furniture.

Heating and Ventilating

There has probably been more research on heating and ventilating than on any other feature of the school plant. Altho there has been rather general agreement on desirable conditions, many codes are still based on false principles. The phase of the problem, which especially requires further study, is methods of achieving conditions which have been determined by research to be satisfactory. This is especially timely because of new technics for producing predetermined temperature, circulation, and air purity.

The following are among the principal subjects on which further research is needed: (a) panel heating installations which are satisfactory and economical for school use; (b) methods of installing and operating and the effects of germicidal lamps and other methods of purifying air; and (c) air changes, especially in toilets, laboratories, and kitchens. Recent studies have rather neglected humidity, and further research may be needed to determine to what extent humidity is important.

Insurance and Fire Protection

Property insurance practices have been materially improved during the past twenty years, but there is still need for vast improvements. More adequate coverage probably could be effected at reduced costs if research data were available on such items as: (a) current fire-loss ratios, (b) the value of extended coverage, (c) methods of calculating depreciation, (d) services received for commissions paid to local agents, (e) state insurance plans, (f) state purchase of blanket coverage allocated by individual local building risks, (g) methods of estimating present worth and insurable values, (h) desirable co-insurance percents for various risks, (i) the incidence of school fires, (j) state department of education participation in fire-safety programs, and (k) safeguarding school records.

Lighting (Conditions for Seeing)

There has been some research and a great deal of pseudo-research in the field of school lighting. The field is still very confused by conflicting opinions, commercial claims, and half-truths. The shift of emphasis from foot-candles to good seeing conditions has made much of the earlier lighting research obsolete. School lighting involves three factors which must be studied in their relationship to each and their effects on balanced brightness within the total visual environment. These factors are fenestration, surface finishes, and artificial illumination.

Following are some of the major subjects on which fundamental research should be undertaken: (a) types of window glass or window substitute materials; (b) amount and placement of areas designed as natural light sources under different climatic conditions; (c) furniture arrangements with respect to multi-lateral natural lighting; (d) shading and shielding devices for reducing glare from natural light sources; (e) colors and types of paints and other finishes on ceilings, walls, floors, furniture, and working supplies; (f) more effective shielding of artificial lighting sources without undue reduction of efficiency; (g) development of low brightness tubes in a lower price range; (h) eye tolerances to brightness and brightness differences, and establishment of standards of brightness balance for eye comfort and visibility; (i) determining differences, if such, between eye comfort and eye efficiency; and (j) study of the accumulative effect of unfavorable seeing conditions.

Maintenance of Plant

The following are some of the plant maintenance problems which need further research: (a) waterproofing, (b) masonry floor treatments, (c) interior and exterior painting schedules, (d) refinishing furniture, (e) treatment of rough interior wall surfaces, (f) refinishing rough masonry floors, and (g) repair schedules.

Maintenance Organization and Personnel

The general lack of adequate personnel and effective organization for plant maintenance calls for further research on such items as: (a) contract maintenance versus maintenance by regularly employed personnel, (b) use of school shop for repairs, (c) use of repair truck for minor repairs, and (d) the county school mechanic for rural school maintenance.

New Materials

There should be continued research on the use of the newer building materials now coming on the market. There will, no doubt, be unsupported claims for some of these new materials, and research will be required to determine the value for school construction. For example, the best grades of hardwood flooring are in short supply. The shortage will probably continue and substitute flooring materials will have to be developed for various school uses.

Operation of Plant and Operational Personnel

The following phases of school-plant operation methods need further research: (a) nonwax floor treatments for rural schools, (b) smoke abatement with ordinary fuels and use of over jets, (c) boiler-water treatments, (d) surface deterioration from use of detergents, and (e) care of shop floors. Some custodial personnel problems are: (a) custodial unit time schedules; (b) custodial work loads; (c) custodial training procedures; (d) custodial employees' unions; (e) retirement benefits for custodians; (f) evaluation of operating efficiencies; and (g) employment, tenure, salaries, and management of custodial employees.

Records and Reports

More uniform systems should be established for recording and reporting property data. Distinctions should be sharpened among the classifications of plant operation, plant maintenance, and capital outlay. More uniform and meaningful methods should be devised for reporting plant values.

Sanitary Facilities

Further research is needed as to the number and location of toilet, washing, bathing, and drinking facilities. Requirements for these facilities have changed with modification in school programming, and will vary for different types of schools. Sanitary facilities represent a considerable investment, and their number, location, and design should be based on continuing research.

Sites

The trends toward more physical education, outdoor education, and community-centered schools all place increased requirements on the school site. Research is needed to determine areas adequate for these many and varied uses, and the best methods of laying out grounds for maximum utilization. Site size and location is also related to types of internal organization, grade grouping, and size of schools. Small primary units are growing in popularity in some cities.

Playground surfacing is a site problem which has not been solved satisfactorily for many types of soils. Facilities for storing and servicing yard tools and equipment need further study. Studies should be made of joint maintenance of school grounds and city parks to reduce costs and improve maintenance of both. Parking and bus loading and unloading have become serious problems. The parking problem is especially acute for colleges located in urban areas.

Further study should be given to types and quantities of playground equipment. Much money is wasted on equipment which serves but little purpose. Site layouts and fencing should be studied in relation to buildings and streets for greater safety and convenience.

Need for Coordinated Research

Many institutions, agencies, and associations are interested in various phases of school-plant research, and some of them have made valuable contributions to the field. Some attempts have been made to coordinate school-plant research on a national scale, but these efforts have as yet been rather ineffective. There is no adequately financed central clearing house for collecting and evaluating research results, coordinating current and contemplated research, and determining and assigning needed research projects. There is a vital need for such a clearinghouse. The job cannot be done merely by expressions of willingness to cooperate and resolutions of good intentions by interested groups. Many talking conferences have been held on this subject, but worthwhile results cannot be expected unless and until competent individuals and institutions are assigned definite responsibilities and provided with adequate financial support for specific projects.

In addition to the cooperation of various school-plant research agencies, the best results will require close coordination in actual research projects. For example, research in acoustics, painting, illumination, and maintenance should be coordinated in a way which will recognize the interrelationships among these factors.

School-plant research should be a cooperative undertaking, but it will require coordination by a paid staff to achieve satisfactory results. Manufacturers must play an important part along with educators, architects, and engineers; but school officials hesitate to accept the results of research based solely on commercial interests. A full-time staff working under the direction of a board representing various groups and interests would probably be the best solution to over-all coordination of noncommercial school-plant research. Such a board might be composed of representatives from such agencies as: The American Institute of Architects, the National Council on Schoolhouse Construction, the National Bureau of Standards, the U. S. Office of Education, the U. S. Public Health Service, The Producers Council, the American Council on Education, and the American Association of School Administrators. It would be neither possible nor advisable to set up a central facility for all school-plant research. Specific projects would have to be assigned to specific individuals at institutions qualified to conduct the assigned research projects.

Such a coordinating agency would require substantial long-range support for a central staff, for institutional direction and scholarships, and for necessary research equipment and materials.

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CHAPTER II

School-Plant Survey Technics

WILLIAM K. WILSON

It is difficult to define as research, technics for determining school-plant needs, if research involves both development and testing of methods. Recommendations evolving from a school-plant survey are based upon long-range predictions and estimates of trends in population, enrolment, educational methods, practices in educational administration and organization, and in methods of financing education. Testing this accuracy of long-range predictions on any of these factors involves time far beyond the three-year cycle of the REVIEW OF EDUCATIONAL RESEARCH. It is possible, however, to point out some new or improved technics for predicting or estimating fundamental data and conditions that may result in sounder recommendations for the expansion or improvement of school-plant facilities.

The problem of school-building needs is paramount today. Thousands of studies of need are being made, ranging from statewide surveys to individual studies of small rural districts. Practically every one of these studies involves predicting enrolment, predicting the distribution of children within the areas studied, evaluating the existing school plant, relating the school plant to the educational program and organization, and estimating the ability of the district to finance capital expenditures.

The following report on technics used in recent school-building surveys indicates some worthwhile and perhaps new approaches to four important factors of a school-building study, as follows: (a) the philosophy given as a basis for encouraging districts to prepare long-range studies of school-building needs, (b) the methods of predicting enrolment, (c) the method used in arriving at a complete picture of the ultimate long-range school plant, and (d) the method used in determining the recommended number and locations for buildings in the long-range plant.

The Philosophy of Long-range Planning

Reavis (4) traced the history of the gradual development of long-range planning of school plants, first pointed out examples leading to the present-day widespread activity and interest in such planning. He emphasized the need for providing authoritative answers to at least six questions when evaluating any given building of a school plant. Briefly, these six questions cover the items of safety and health, relation of the building to the educational program, operation and maintenance cost, flexibility for future change, the character of the school site, and the artistic effect of the building on children and community.

Strayer (5) outlined four factors necessary in studying the buildings and grounds of a school system, as follows: evaluation of the school buildings, studying population and enrolment trends, basing recommendations for need on the utilization of the existing facilities, and setting up steps for the development of the complete school plant. Under each factor general sources of material were cited.

Wilson (7) discussed the advantage of long-range planning and outlined the method of such planning under five steps: outlining the ideal school plant necessary to do that job, evaluating the existing school plant, setting up the practical plant expansion program thru the adaptation of the usable existing facilities to the ideal plant, and setting up a schedule for the orderly development of the ultimate practicable school plant.

As an argument for satisfactory school-plant facilities, Carpenter (2) set up the objectives of education in a "Code of Rights." He developed the following five principles to be followed in the planning of school-building facilities: health and safety, planning for flexibility in meeting changes in education, determining the best use to be made of existing facilities, consideration of beauty and dignity of a school building, and characteristics of the school site. He also listed fourteen types of information that should be collected in making a school-building survey.

Bogner, Cotton, and McLeary (1) discussed the need for and development of long-range planning and set up five requirements: developing the plant in terms of the educational program, considering the possible changes of the future educational program, planning the buildings and facilities for expansibility, overcoming the inadequacy of the existing facilities in terms of a complete educational program, and determining financing in terms of actual building needs.

Predicting Enrolment

Wilson (8, 9) developed a technic for predicting enrolment from recorded births by analyzing the trend over a period of years between resident births and enrolments accruing from those births. This ratio was then used for predicting future enrolments from the latest recorded resident births.

Developing the Ultimate Plant

In arriving at the final recommendation for the locations of the buildings in the ultimate school plant, Wilson (6, 8, 10) introduced a factor not heretofore used. In his surveys he used three terms: the existing school plant, the ideal school plant, the ultimate school plant. In the ideal school plant, the locations of all buildings determined as to type and desired capacity are located ideally without regard to restrictions on possible actual locations. Then, following the evaluation of the existing plant and the determination of the best uses to be made of the units of this plant, the ultimate school plant was developed as an adaptation of the usable existing facilities to the ideal school plant.

Determining the Number and Location of Buildings

Wilson (6, 7, 8, 10) developed a method for determining the number of elementary buildings in the ultimate school plant by using an optimum enrolment range for each school, and by determining thru zoning data the approximate area of residential land needed when saturated to provide the number of children within that range. Natural barriers and acceptable walking distances for children were contributing factors in the method. It is claimed that this method eliminates the necessity for accurate prediction of total elementary enrolment over a given period of time. The method was used also for junior high schools in the New Haven Building Survey. Engelhardt (3) used this method successfully in a survey of elementary and junior high school needs for Northeastern Queens, New York City.

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CHAPTER III

Planning Procedures

CHARLES W. BURSCH

THE planning, financing, and construction of an adequate and appropriate school plant is educationally important, very complex, requires large sums of money, and takes months or years to consummate. There is a substantial body of literature dealing with the subject. However, it has been and is today devoted principally to *what* should be found in a school plant and *how* it should be financed. A portion of the literature deals with procedures in planning. It is concerned with devices for improving and controlling the processes necessary to give reasonable assurance that the many desirable participants have made their full contributions and that the facilities chosen by them will actually appear in the completed building. It is with this portion of school-plant literature that this chapter deals.

Current emphasis upon the functional aspects of school-plant planning and upon the desirability of having each plant "tailored" to the specific educational program to be housed therein creates the necessity for following a carefully planned and detailed procedure. So does the presence of an increasing number of legally constituted plan-review and approval agencies. Also the subdivision of architectural and engineering services into many specialties emphasizes the practical necessity to the school administration of control procedures. Each specialist should do his part but should not unbalance the whole enterprise by overemphasis of his specialty.

City-School Districts

The basic principles, as well as specific recommendations for each school, resulting from the planning procedure adopted by Detroit, Michigan, were reported by Browe (1). A highly significant procedure for broad public consideration of and participation in their building survey report of the Cincinnati public schools was cited by Holy and Herrick (19). Changes in tentative recommendations brought about because of public participation were listed. Steps adopted by board of education resolution to implement the survey recommendations established a procedural pattern which involved provision of additional staff, the setting up of staff committees, and the routing of committee responsibility thru the superintendent of schools.

The Manual of School Planning for the City of New York (30) contained a division on planning procedure which designates routing of information, plans, and decisions, and defines in detail what is to be included in required documents. Another New York City document on Operation-Maintenance Requirements for School Buildings (31) had a twelve-page section dealing with procedure upon the completion of a new building.

The extent of effective joint planning between large city-school districts and community-planning bodies was reported by Grieder (17). He also described the machinery of cooperation found in some of the cities studied. Long (23) described staff committee organization and procedure in participating in building planning in Portland, Oregon. Analysis of community background data and involvement of school staff, community leaders, and a competent architect was recognized as important in the planning process by Church (8). How a school-building program is handled in Cleveland, Ohio, was discussed by Murphy (28).

Frequent meetings of a survey committee with groups of teachers and other interested citizens of the parish were found by White and Smalling (41) to help in solving building planning problems. Engelhardt (9) pointed out how the preparation and continuous revision of a building manual for a school district serves as a focal point for assembly and organization of the complex and ever changing materials pertinent to school planning and construction problems and procedures.

State Departments of Education

Some state departments of education have emphasized planning procedures both as a means of improving school plants and facilitating legally required approvals. The New York State Department of Education (32) stressed the importance of a cooperative study of local needs and periodic participation by the Division of School Buildings and Grounds thruout the planning period, defined thoroly preliminary drawings, unfinished working drawings and final working drawings and specifications, and stated how each stage was to be presented for review and approval.

Carpenter (6) stated principles that should govern the development of a building program, listed types of information to be assembled, and included a checklist designed to facilitate the following of important items from the recommendation stage thru preliminary plans and then into the final plans. His statement of precautions to be observed in voting bonds is quite complete.

The Michigan State Department of Education (25) in two chapters clarified the relationship of the state to school-building projects and gave detailed information on the conduct of a building program. The Minnesota State Department of Education (27) organized its material on planning procedures in a similar manner. The Oregon State Department of Education (33), under the chapter heading "Procedures in Planning School Buildings," stressed planning steps, architectural services, sources of planning information, need for community participation, and common procedural errors to be avoided. Similarly the West Virginia Council on Schoolhouse Construction (40) dealt with planning a school-building program and the California State Department of Education (5) documented agreement by parties officially concerned on basic planning considerations prior to authorization for the architect to begin production of final drawings and specifications. Wanamaker (38) explained how the Washington state aid for school construction program was worked out cooperatively on a long-term basis. Grieder (16) found that an organized pool of consultants drawn from the universities and colleges in Colorado was able to render complete and disinterested planning services to school districts at low cost.

General Studies

Devoted completely to procedure is the bulletin by Strayer, (37) dealing with planning for school surveys. This bulletin is the type of service instrument designed to assist a school administrator, not familiar with survey practice, to conduct a thoro survey of his schools. Marshall (21) developed twelve steps designed to be of assistance in many school-plant planning situations. He emphasized the need for each school to develop its own planning schedule. The necessity for school-building adaptations to accommodate changes in educational programs is emphasized by Engelhardt (10). He outlined planning steps to guide boards of education in effecting the desirable changes.

The factors to be considered by a schoolboard in developing a plan of action in regard to plant provisions or improvements was presented by Perkins and Cochran (34). Foy (14) gave twelve suggestions on how to proceed in planning school buildings but emphasized that each community must develop its own formula. Eleven steps in planning were developed by Flesher and Holy (13) for assistance to communities that wish to proceed with a thoro study of their school-building needs. Kimes (21) emphasized the need for careful organization of the planning process so that the school administrator can better discharge the heavy responsibility involved.

Holmes (18) undertook to assist school administrators understand the school-plant planning problem as a comprehensive whole by means of a complete and practical outline with comments. Procedures designed to accomplish orderly progress, wide participation, and critical evaluation of each step in planning school buildings were outlined by Lewis (22). Engelhardt (11) gave ten categories of problems associated with planning building programs. He illustrated the discussion of categories with maps, diagrams, and floor plans. The detailed plan of how the regional planning commission of Los Angeles County cooperates with school districts in the selection of school sites was described by Bursch (2).

Because the problem of planning school buildings is beyond the competence of any one individual, Miller (26) assigned the role of coordination to the superintendent of schools and specific areas of planning to others having specialized competence. A significant report of the planning procedure used for a specific school plant was made by Killham (20). Bursch and Reid (4) devoted almost an entire book to the procedure of administering a planning and building program of a school district and encouraged school administrators, planners, architects, and engineers to find original solutions in terms of local situations thru independent and creative thinking. The National Council on Schoolhouse Construction (29) stressed the process of school-plant planning as a cooperative undertaking involving many persons. Twenty steps in planning school-building programs were developed by Gregg (15) as a means of giving assurance that capital outlay funds would be well spent and to assist in making the building planning program continuous. The considerations necessary to produce a community type school plant were discussed by Sohn (36). He especially stressed the relationship of school planning to zoning authorities and to the development of the neighborhood concept.

How integration of the contributions of many persons and groups was achieved to produce a functionally designed school building was reported by Fawcett (12). Whitehead (42) explained stages of work in educational planning preliminary to plant planning, with special reference to the place of educational consultant services. How orientation of a school superintendent and an architect to the complex problems involved in planning a high-school swimming pool could be accomplished was reported by Chastain and Weihe (7). Weaver (39) recommended the use of scale models of equipment results in superior shop layout arrangements. His suggestions and illustrations made use of that method practicable. Bursch (3) pointed out the importance of the local school-plant staff composition, organization, and assignment in assuring that appropriate facilities are provided. His ten-point program of action and conclusions stressed the need for improving planning procedures and control technics as the most promising basis for fulfilment of the school superintendent's responsibility in the school-plant field.

Summary

A substantial number of experienced school-plant personnel have published their ideas on planning procedures. A much smaller number have reported evaluations or results of the procedure. There is evidence that many school districts, especially those in the larger cities, have not published descriptions of the planning procedures they are using. It can scarcely be doubted that the publication of such reports would facilitate progress in school-plant planning.

Of even more value at this time, however, would be the production and publication of more reports of the type done by Seagers (35) in his dissertation. In this study he gave sufficient procedural detail to be of real assistance to those who embark seriously upon a program involving many planning participants. He also gave substantial attention to the question of values accruing because of wide participation.

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CHAPTER IV

The Elementary School Classroom

CARL PAYNE

THE elementary classroom is the first school home of children embarking upon the school career. Because of the invaluable and lasting impressions of first experiences, there is a growing feeling that more attention should be given to planning this room. Very little research of a formal nature is available to substantiate the idea that recently constructed elementary classrooms are more effective in providing a better basic educational program. There are, however, many opinions that much progress has been made in the thinking of what constitutes a good elementary classroom.

Simon (28) and Engelhardt (10) pointed out that the problem of housing children for educational purposes is a human problem concerned primarily with the child. Simon (28) stated that younger children present the more intensified problem because of the importance of first impressions in a child's development. Engelhardt (10) indicated that when teachers plan classrooms to meet their needs and those of the children, the teachers will be challenged not only to improve the physical environment but also to consider the philosophy of education and the effectiveness of the whole teaching process.

General Features of the Elementary Classroom

According to Engelhardt (10), certain aspects of the planning process, such as human relationships and the design of a classroom in terms of all aspects of child development, are usually ignored. Perkins (25) reported that the child should be prepared to live happily and the classroom should give him adequate tools with which to learn. Ramsey (26) concluded that there is no such thing as a wholly desirable classroom as the human element insures that no classroom will ever meet perfectly the needs of all the persons who will use it thruout the years.

It is apparent that classroom standardization is fast decreasing. Reavis (27) thought that the feature of school buildings presenting the greatest problem in functional planning is the classroom. He attributed the excellence and the rapidity of progress in school construction to functional planning. Sutherland (29), Wilson (33), and Ramsey (26) opposed any standardization in classroom size. Wilson (33) stated that the elementary-school plant was generally in poorer condition than the secondary school. He condemned the practice of turning the old high-school plant over to elementary use. Ramsey (26) pointed out that the ideal classroom should possess flexibility.

The Department of Elementary School Principals and the Research Division of the National Education Association (20) sent out a questionnaire to a random selection of twenty-five principals and sixty-three classroom teachers in 1945 to find out what building facilities they believed should be provided for a modern elementary-school program. The report indicated that the most desired item was increased classroom space. More outdoor play and recreation area and additional and adequate storage space of different kinds ran a close second. Many of the teachers and principals expressed an opinion in favor of separate toilet facilities for each room and a sink with hot and cold water in each classroom.

Ramsey (26) discussed the advantages of first floor location for elementary classrooms. Baxter and Bradley (3) pointed out the influence of environment upon the effectiveness of the elementary program. Heffernan (13) found that no field of educational endeavor has shown greater progress in recent years than that of creating improved educational environment.

Size and Shape

Perkins (25) discussed the elements determining classroom size and arrangement. The inadequacy of the traditional elementary classroom was pointed out by Otto (23). He stated that the classroom need not be rectangular. There is considerable agreement that the elementary classroom size should be increased. Lieuallen (16) found that thirty square feet per pupil is the minimum amount of required space, exclusive of wardrobes or cloak rooms. Elsbree (9) recommended from twenty-six to thirty square feet per pupil for those elementary grades above the kindergarten and forty square feet per pupil for the kindergarten. Simon (28) suggested a minimum width of twenty-six feet for the elementary classroom. Sutherland (29) omitted any recommendation of specific class size. He is opposed to any standardization in classroom size.

Features and Equipment

A separate workroom was recommended for all primary classrooms by Otto (23). He advocated a separate room designed as a laboratory for art, handicraft, and science for the intermediate grades. Ramsey (26) suggested a workroom with such special features as an elevated floor for occasional use as a stage and sound-proof curtains. *The American School Board Journal* (2) described the equipment and special features of a work alcove. Fawcett (11) discussed a project room for use by elementary children, both primary and intermediate. He found that sliding glass doors separating the project room and the main classroom shut out noise and enabled supervision.

Beard and others (4), Hosler and Swanson (15), and McClure (18) recommended direct access to the outside from the classroom. Beard and others (4) advised ramps to ground level instead of steps. Ramsey (26) found that the adjoining outdoor classroom is gaining in popularity because the development of certain skills and knowledge is impossible in the indoor classroom.

Heffernan (13) pointed out the advantages of having the outdoor terrace adjacent to the classroom on the same level as the classroom. She advocated a shelter to enable greater use of the outdoor area adjoining the classroom, pointing out the health advantages of outdoor study and play. Begg (5) described the Manhattan Beach School in California where one entire side of each classroom is glass-framed in steel. A wide sliding steel and glass door can be opened so that the classroom includes an adjoining individual terrace. He found the close relation of indoors and outdoors extremely successful in the warm climate.

Marsh, Smith, and Powell (17) recommended an outside work terrace of cement. Payne (24) suggested asphalt or similar surfaces for some portion of the play area to permit play out-of-doors following a shower. It is generally agreed that play areas adjoining elementary classrooms should have some turf area, and some asphalt space. Beard and others (4) recommended some space for planting.

The Michigan State Department of Public Instruction (19) recommended pupil's project storage as a necessity in the elementary classroom. It found that the need for the large general storage is lessened when elementary classrooms are provided with sufficient cupboards and shelving. Nichols (21), Elsbree (9), Credle (8), and Lieuallen (16) favored project lockers or cubicles. Credle (8) described the optimum size for storage chests and discussed the best location for them. *The American School Board Journal* (2) reported that recessed cabinets and modernly constructed bookcases provided adequate storage space in a primary school when cupboards in the cloakroom were available to the pupils as well as to the teacher. Beard and others (4) recommended storage space under window seats in classrooms housing children from four to seven years of age. Elsbree (9) found advisable a narrow counter with adjustable shelves constructed along the wall under the windows.

The American School Board Journal (1) reported the use of the classroom wall adjoining the corridor for a vented wardrobe, a teacher's supply closet, built-in files, and storage shelves. The Michigan State Department of Public Instruction (19) found ventilating corridor lockers good in some elementary schools. Elsbree (9) pointed out the necessity of either lockers, a wardrobe, or a cloakroom for each classroom. *The American School Board Journal* (2) indicated that individual numbered locker boxes with a continuous built-in bench below, running the length of the walls, were in satisfactory use. Ramsey (26) pointed out that lockers outside of the classroom were a substitute for cloakrooms.

The American School Board Journal (1) found separate toilet rooms for boys and girls in the elementary classroom advisable. Mosler and

Swanson (15) indicated a preference for adequate centralized toilets for the primary school. McClure (18) found that the washroom and toilet room located off the work alcove an efficient arrangement. Otto (23) indicated that the individual toilet room was preferred, with the possibility of a separate toilet room for boys and girls above the third grade. Beard and others (4) reported that one toilet room for boys and one for girls for all classrooms from grade one thru grade six was the choice of many elementary teachers. Tallman (30) advised special toilet facilities for each of the several grade levels—kindergarten, primary (1-3), and upper grades (4-6). Fawcett (11) described the elementary classroom that had a common toilet for boys and girls leading off the clothing room. Elsbree (9) noted that toilet facilities in the primary classroom probably have their greatest usefulness in grade one.

Credle (8) and Vincent (31) recommended a lavatory and a drinking fountain for each elementary classroom. Begg (5) described the Manhattan Beach School which was equipped with a sink in each classroom. *The American School Board Journal* (2) described a primary school that had work alcoves equipped with a sink adjoining each cloakroom. Ramsey (26) included a drinking fountain and a sink as essential equipment for each classroom.

Hosler and Swanson (15) found that a stage in one end of the kindergarten was of value when the room was used for community purposes. Sutherland (29) pointed out that movable partitions in a modern classroom assist the school to adapt itself to the changing needs of teaching. Cappa (7) indicated that the trend is toward less chalkboard and more display space. *The American School Board Journal* (1) described a front wall of a classroom equipped with reversible tack and chalkboards of the easel type and swinging chalkboards. It pointed out that light cream color for chalkboards had some advantages.

Built-in work benches with shelves underneath were recommended by the Michigan State Department of Public Instruction (19). Knee-and-toe room were advised, and wall cupboards and tool racks over the benches were recommended. Hamon and Smith (12) pointed out that the types of equipment should be determined early in the planning so that proper electric outlets, drains, gas and water lines, chalkboards, and bulletin boards could be properly placed. McClure (18) indicated that work alcoves should provide space for workbenches and sandtables.

Bruner (6) advocated twenty running feet of bulletin board space at least four feet high. Otto (23) recommended some built-in shelves, closets, and drawers. He pointed out the possibility that there has been too much built-in equipment and advised the consideration of book shelves on wheels, thus permitting greater flexibility of use within the classroom.

Wiley and Wiley (32) indicated that there is a demand for furniture that is more effective in carrying out the program of the modern school and is functional from the standpoint of the needs of the growing child. Movable furniture was advocated by Nichols (21), Begg (5), McClure (18), Lieuallen (16), and Fawcett (11). Nichols (22) discussed those aspects of planning that are peculiar to the nursery schools, largely disregarding those common to all school buildings. Ramsey (26) advocated that children's sizes should determine the height of all facilities such as sinks, cabinets, blackboards, pictures, and so forth.

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CHAPTER V

Planning the School Building for Community Use

DON L. ESSEX

FOR years educators have been advocating that the school plant be designed to provide not only for the educational needs, but also for many, if not all, the social, civic, recreational, and cultural needs of the entire community. It is felt that if this can be done, in many instances inefficient utilization of public buildings and duplication of costly building materials can be avoided. Furthermore, it seems certain that as the school and community draw closer together, interest in and support of the regular school program by the community increase accordingly.

Notwithstanding this widespread interest in planning the school building for community activities, few writers in the field of school-plant planning have come to close grips with the problem. That is, there is very little literature on *how* to plan the school building for community use.

The most ambitious attempt to define and describe the community school plant was undertaken by Engelhardt and Engelhardt. (3) Their volume deals primarily with large school districts and is centered around adult activities. Many illustrations of rooms and other plant areas planned for various types of community activities are given, and examples of communities which have organized programs of community interest which are housed in the school building are discussed. This book is helpful to large, fairly wealthy districts, but has only narrow implications for relatively poor rural communities where the school building may be the only public building in the community.

The New York State Department of Education (18) was concerned primarily with rural school districts and pointed out that few if any additional facilities over and above those commonly found in a well-planned school building are needed to take care of the usual community activities. Many rooms can be used dually by both school and community. Five factors must be given careful consideration: (a) location in the building of facilities used by the community, (b) distribution of heat for unit and room control, (c) provision for adequate storage space for equipment, (d) special appointments and service features, and (e) provision for toilet facilities.

Perkins and Salmon (19) agreed that regular school facilities can be used for community affairs and said that special rooms for community purposes are a luxury. Regarding extra costs involved in planning a school building for community use, Essex (5) emphasized that separate plants to take care of community needs would be a far more costly proposition. Hamon (8) drew plans for a small community-elementary school building and called attention to the following features: (a) multipurpose room; (b) large stage; (c) kitchen for school lunches, community suppers, and homemaking; (d) handicraft room; (e) library; (f) health room; (g) gate to close off classroom portion of building; and (h) work counter, storage, and display board space in each classroom. McCharen (15) said that the school library should be a vital part of neighborhood life and discussed the planning of the library for both school and community use. Engelhardt (2) said that every community should provide its own list of common problems and concentrate on those not cared for by community agencies.

Schott (20) listed the adult organizations having activities which can properly be housed in the school building, and developed a measuring device for evaluating a "community service area" school plant. This device contains no items that are peculiar to the planning of a school plant for community use.

Food Service and Preservation

Marshall (14) reported that food service for community affairs can be offered without extra facilities being provided.

The National Council on Schoolhouse Construction (16) listed four general types of food service facilities: (a) complete preparation, service, and dining facilities planned for table service; (b) complete preparation, service, and dining area planned for cafeteria service; (c) kitchenette type of food preparation, but dining provided for in the classrooms, assembly room, gymnasium, or other area which is used during the major portion of the day for other purposes, and (d) central food preparation for several school lunch departments in school systems with facilities for serving and dining in each school. Credle (1) pointed out that the community school is the logical location for the community cannery, the food dehydration plant, and the quick-freeze unit.

School-Community Recreation Programs

Hjeite (10) listed three elements in school-community planning for recreation: (1) neighborhood playground—usually served by an elementary school, used mainly by children; (2) district recreation center—a constellation of neighborhoods, including such facilities as swimming pool, picnic ground, gymnasium, large athletic field, batteries of tennis courts; (3) regional place of recreation—beach, lake, wooded area, etc. as schools ordinarily have no facilities of this character to offer. Essex and Miles (6) pointed out that school recreation facilities must be specially planned for community use if they are to serve the dual role economically and adequately. Graff (7) suggested two divisions of "grounds": one type controlled by other community agencies, but available to the school; the other, under the complete administrative control of the school.

The National Recreation Association (17) suggested dual use of many rooms, such as kindergarten rooms for glee clubs, drama clubs, orchestras and the like; assembly hall for indoor baseball, basketball, and volley ball. Gymnasiums, auditoriums, homemaking rooms, shops, music rooms, libraries, cafeterias, teachers' rest rooms can be taken over for recreation with little change beyond the addition of storage closets. The Association also listed the following rooms as essential for a good school-community recreation program: quiet game room for cards, parchesi, chess, checkers, etc.; active game rooms for basketball, punching bag, Indian clubs, etc.; billiard and pool room; lounge; reading room; check rooms.

The Neighborhood-Primary School

With the extension of the school program downward to include pupils of nursery school age and with the increase in traffic hazards, particularly in congested residential areas, much attention has been given during the past two years to the planning of neighborhood-primary schools.

Hosler and Swanson (11, 12) pointed out that the neighborhood-primary school brings home and school closer together; may be made an integral part of and serve a comparatively small homogeneous residential area; can be less institutional in size, scale, and program than the traditional school; and that, with automatic heat control, a matron may be used instead of a man custodian. They described a proposed neighborhood-primary school building for Allentown, Pennsylvania. Hart (9) recommended small neighborhood-primary schools for ages five to seven located at strategic points a distance of three, four, or five blocks from large elementary schools. These would be one-story buildings, containing from four to six classrooms with low ceilings and window sills, having few accessory rooms, and located on small sites. Engelhardt and Huggard (4) described this type of school as a home-school unit for nursery, kindergarten, first- and second-grade pupils, and pointed out its value as a community center.

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CHAPTER VI

School Lighting

PAUL W. SEAGERS

THE chapter on school plant lighting by Gibson (6) in the February 1945 issue of the REVIEW OF EDUCATIONAL RESEARCH is still one of the best sources of information today on school-plant lighting. The quality of light as determined by a balanced brightness is receiving more attention than any other phase of lighting at this time. However, higher levels of intensity are being used, with the National Council on Schoolhouse Construction (15) recommending twenty to forty foot-candles depending upon the type of activity.

Logan (14) went back to nature to determine comfortable seeing conditions. He divided the entire field of vision into six horizontal zones and by means of a flux meter he was able to determine the distribution of light in those zones. He said that research has shown that the eyes work with the field of view as a unit and, therefore, engineers should treat it as a unit. Harmon (8) took issue with Logan and some other engineers and said that to produce efficient vision and comfortable seeing, the illuminating engineer must be concerned with more than quantities of light and distribution of these quantities. He must be concerned with qualities for given tasks based on sound visual physiology for that task. He must know the total physiological effect of the light media with which he is working. He must plan for today's efficient seeing in terms of tomorrow's ocular comfort as well. He must not be a mathematical manipulator of the physical media for producing light, but a human engineer in the field of visually centered activity. The Harmon technic of classroom lighting, as it was set up in the Rosendale School in Austin, Texas, was described in an article by Whitcomb (22).

Daylighting and Classroom Lighting

A number of technics in providing visual comfort and efficiency in the classroom have been either tried or advocated thruout the country. Haskell (9) recommended sixteen ways of daylighting a classroom, among which are the sloped ceiling and louvered awning and the directional glass block. Paul (18) wrote a book in which he described the use of a directional glass block and attempted to show that the brightness of that block at practically all positions of the sun is well within the recommended tolerated brightness. Wright (23) suggested bilateral lighting with clerestory windows on one side. He also suggested fourteen-foot ceiling heights, four-foot window sill heights, fixed louvers of metal for all windows, high reflection factor paint on the window sides, 80 percent reflection factor paint on the ceilings, 55 percent to 60 percent reflection factor on the walls and 40 percent reflection factor on the floor, furniture, and woodwork. He would eliminate all glass panels in doors leading from classrooms directly out-of-doors to reduce brightness contrasts in the room. He suggested also painting blackboards and chalkboards to harmonize with wall color.

Allphin (1), in setting up an illumination experiment in a Massachusetts school, attempted to reduce the sky brightness at forward angles. He selected appropriate colors with high reflection factors and had the lights monitored by a pupil who had a special lighting indicator fastened to his desk. This lighting indicator was a simple light meter with a special face which hid the needle when the meter was receiving an approved amount of light, but which became visible when there was not enough natural light in the classroom. Gibson and Sampson (7) emphasized that the schools need a visual environment that makes "seeing comfortable, easy, and fast." Areas of either high or low brightness should be kept to the smallest area practicable. If they cannot be eliminated or corrected they should be kept as far from the line of sight as possible. Biesele (2) stated that it is desirable that the average brightness of the visual task be slightly greater than, but not more than, three times as great as the balance of the central field. He said that artificial lighting systems must fulfill the same requirements as the natural lighting systems; therefore, there should be enough light on the work to provide satisfactory brightness levels, and brightness ratios in the field of view should be within the same limits.

Darley (4) thought that the provision of seeing conditions in the classroom should not be predicated upon the needs of tough, normal eyes, but upon those of the most sensitive and defective eyes in the group. He said that some of the common complaints about the higher intensities furnished with fluorescent lighting is not due to the fact that there is too much light but from the high disturbing brightness ratios within the field of vision of the individual. Bursch and Gibson (3) said that natural light is not superior to incandescent or fluorescent light for critical seeing purposes. The kind of light, within the common limits of natural or daylight and artificial light from incandescent or fluorescent lamps, has no significant effect upon the seeing process. The important thing is not how much light is striking the task but how much light is being reflected back from the task.

Brightness Ratios

James (13) paid particular attention to the brightness ratios thruout the entire visual field. He also showed that altho fluorescent fixtures are very expensive they consume at least 40 percent less electricity than incandescent for the same illumination level and, therefore, over a period of approximately ten years, the over-all costs of illumination by fluorescent fixtures would be approximately that of incandescent fixtures. Neidhart (17) said that the lack of proper illumination has a profound psychological effect upon children. Children cannot be blamed for not liking school if their classrooms are dingy with dark woodwork and drab walls. Drudgery can be taken out of school work in bright cheerful surroundings. He suggested the use of a semi-indirect luminaire which directs about 60 percent of the light upward and 40 percent downward. The Illuminating Engineering Society (12) discussed the comfort-discomfort threshold and furnished a table which compares the actual brightness of light sources with the established tolerable brightness of these sources and also goes more fully into brightness ratios.

Principles of Good Lighting

Altho there have been a large number of applications of the principles advanced in the material reviewed above, only four outstanding applications have been selected for this chapter. The lighting of the offices and library of the Harvard School of Business was one of the better applications. It was described by Holway and Jameson (10). The research group in charge of this demonstration set up a list of work rules as follows: first, all sources of glare should be eliminated; second, the lighting should be distributed evenly over working surfaces and as far as possible thruout the entire room; third, the quality of light should be such that it is neither unpleasant nor uncomfortable over long periods of visual work; and fourth, the amount of light falling on the working surface should be of the order of 20 foot-candles. Another outstanding example of proper applications of good lighting principles is given in the report of a two-year study made jointly by the Public Buildings Administration and the Public Health Service under the direction of the Federal Works Agency, Washington D.C. (5). For this study the environment of a card punch subsection of the Bureau of Internal Revenue was changed by bringing up to the proper light reflection factors the ceiling, walls, furniture, equipment, and floors of the room. Studies were then made of the percent of errors of the employees, the turnover of employees, and the psychological effect of the new environment. New fluorescent lighting was added, which gave not only a higher intensity of illumination but a much better general distribution.

Putnam and Anderson (20) discussed the application of good lighting principles to the rehabilitation of classrooms at the East Cleveland, Ohio, and Cleveland Heights, Ohio schools, as well as selected schools thruout the United States. Their pictures and descriptions of before and after rehabilitation are excellent. They also set up a comparative cost analysis for lighting new school classrooms, as well as for relighting existing classrooms. Putnam (19) showed the application of good lighting principles to drafting rooms at the Case School of Applied Science. The need for a higher general level of illumination and the reduction of reflected glare is especially significant in drafting rooms.

Among the general pamphlets on lighting schoolrooms, two are outstanding. The first is *Teaching about Light and Sight* published by the National Education Association (16) and the second is a more technical but easily read pamphlet, *On Lighting School Rooms* published by the U. S. Office of Education (21).

For all technical information concerning illumination the *I. E. S. Handbook* (11) is an authoritative guide.

Summary

Intensity—Most research agrees that the intensity of lighting at desk level in classrooms should lie somewhat between 20 and 30 foot-candles.

Quality—1. Luminaire brightness: The brightness of the luminaire should come well within the range of tolerated brightness for that particular fixture and the room it is to be installed in, as found in the tables of the *I. E. S. Handbook*. 2. Brightness balance: There should be a maximum ratio of 3 to 1 between the task and surroundings; 10 to 1 between the task and remote surfaces; 20 to 1 between luminaires or windows and adjacent surfaces; and 40 to 1 anywhere within the normal field of view. This calls for ceilings with the reflection factor of at least 85 percent, walls 60 percent, wainscoting and trim 40 percent, floors and furniture 30 percent to 40 percent, and chalkboards at least 20 percent.

Daylight Control—Many efforts have been made to control the daylight in the classroom and give a better over-all distribution of natural light. Bilateral and clerestory lighting as well as the use of a directional glass block, baffles, screens, outriggers, and other equipment have been used successfully under certain conditions. At the present time they are not recommended for all situations.

Maintenance—Regardless of the type of illumination a poor maintenance program will unbalance the illumination in any room. A good checking and maintenance program is a must for all schools.

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CHAPTER VII

Heating, Ventilation, and Sanitary Facilities

I. O. FRISWOLD

During the period covered by this review, the most noteworthy developments in heating, ventilation, and sanitary facilities appear to have been (a) the publication of the New York State Education Department heating and ventilation recommendations, (b) widespread interest in radiant (panel) heating, and (c) reports dealing with the study of airborne infection. Altho a great deal of space has been devoted to heating and ventilation, the attention given to sanitary facilities in the literature of this period has been negligible.

New York Heating and Ventilating Recommendations

Essex (14) described how New York State in 1940 amended its ventilation laws to require merely that plans for any school construction project should not be approved by the commissioner of education unless provision was made in them for heating and ventilation facilities adequate to maintain healthful and comfortable conditions in the classrooms and study halls.

The most complete report of the New York action was presented by the State Education Department (41). This report contains a discussion of the physiological and psychological objectives involved in providing a satisfactory thermal and atmospheric environment, standards of performance, and methods of attainment. The regulations needed to implement the new statutory requirement were adopted by the Board of Regents on November 16, 1945. They specify design operative temperatures and corresponding room air temperatures to be met for various types of space or levels of activity, a maximum air temperature gradient of 5°F from floor to sixty inches above floor, and that air velocities in zones of occupancy shall not exceed twenty-five feet per minute. Where schoolrooms are used in summer, air-cooling equipment may be required.

Ventilation, "atmospheric hazards and quality," provisions are as follows:

1. In classrooms, a minimum air change of ten cubic feet per minute per occupant. For effective thermal operation in mild weather a design factor of fifteen *cfm* is desirable.

2. In rooms planned for close assembly, a minimum air change of ten *cfm* per occupant shall be provided in order to remove odors. Additional air change, depending largely upon wall exposure, may be required for effective thermal operation in mild weather.

3. In rooms where there is danger of toxic substances occurring in large concentrations or where odors are likely to be strong or where overheating is

likely to occur, special ventilating equipment, adequate to relieve the situation and entirely independent of the ventilating system serving the rest of the building, shall be installed.

4. With plans and specifications, a brief, clear, and nontechnical description of the heating and ventilating system together with instructions for operation are required.

The regulations are aimed at two objectives: (a) to provide proper thermal conditions, and (b) to eliminate odors and toxic substances from the atmosphere. Relative humidity is regarded as relatively unimportant. Recirculation of air is considered to have no value except to preheat a cold unoccupied room. Air disinfection is regarded as important but it is felt that at this time no recommendations can be made or standards set for controlling air-borne infection for lack of adequate reliable data.

Radiant (Panel) Heating

A great deal of attention has been given to radiant or panel heating in technical and nontechnical publications during the period covered by this review. Only a sampling of the less technical references can be mentioned here.

Alyea (2) presented an overview of what radiant heating is, how it works, its advantages, types, problems of design and control, and how ventilation may be provided in connection with this type of heating system. Kump (31) among others described applications of this system to school buildings. The advantages and disadvantages of radiant heating, and comparisons between this and other systems of heating have been treated by several authors. Hayes (18) described radiant heating briefly and enumerated some of the advantages claimed for it. Bursch (7) presented the opinions of sixty-five school architects regarding the use of radiant panel heating. He reported that the trend in California is toward this type of heating for school buildings. Druse (13) suggested that the emphasis on radiant heating has created the erroneous impression that other heating methods will soon be obsolete. Lewis (34) pointed out that warm air as well as steam or hot water is a carrier of heat that can be employed in radiant heating systems. The advantages of radiant base boards (20, 29) appear to be warmer floors, greater cleanliness, lower under-ceiling temperatures, elimination of drafts, reduction in fuel consumption, and full utilization of floor space as compared with small tube cast-iron radiators installed in open recesses under windows. Robertson (44) enumerated the advantages of electric radiant heat which he maintained is economically practical on electric rates of one cent per kilowatt hour.

It is of interest at this time, when the application of radiant heating to school buildings is receiving so much attention, to learn that the earliest true radiant heating system thus far found in this country was installed in the floors of a two-story, four-room schoolhouse in Glen Parks, a town which is now part of Gary, Indiana (10, 20).

Control of Air-Borne Infection

According to the *American Journal of Health* (3) the control of air-borne infection presents a broad new field of environmental sanitation that may prove as important to human health and welfare as has the control of disease-producing bacteria in milk and water supplies. Answers are being sought to two basic questions: (a) In what places, and under what conditions, is the problem of droplet nuclei of sufficient importance to warrant specific programs of control? and (b) Where control of microbic content of air seems desirable, what methods are most effective and most economical?

Mudd (36) presented an excellent overview of current issues and the available evidence revealed by a study of seventy-two references dealing with various aspects of air-borne infection. He attacked the argument that the elimination of respiratory infection is undesirable because it may make people "immunologically soft"; supported the thesis that the money costs of preventive measures shrink to comparatively trivial figures compared to what it costs to leave air-borne infection uncontrolled; and advanced the conclusion that the means, consisting of ultra-violet radiation, dust-suppressive measures, and the use of germicidal vapors of hypochlorous acid and of propylene and triethylene glycol, were at hand to render air safe for human occupancy.

The *Journal of the American Medical Association* (25) reported that the amount of air-borne infection is greater than it was formerly believed. Experimental studies conducted by or for the army and navy during the war years such as those reported by Wheeler and others (52), and Bigg, Jennings, and Olson (4, 5, 24), all produced encouraging evidence that air-borne infection can be controlled in some measure. However, a cautious, critical viewpoint regarding the effectiveness with which air-borne infections can now or have been controlled was expressed by the Commission on Air-Borne Infection (11) and the National Research Council (37).

Dust serves both as a carrier of pathogenic bacteria and viruses and as a shield of air-borne pathogens from destruction by ultra-violet radiation and germicidal vapors, according to Mudd (36). Air samples collected by Buchbinder and others (6) in six New York City schools indicated that the average number of bacteria in the air was largely influenced by the amount of dust that was present. Harris (16) maintained that the only effective way to remove fine particles, less than one micron in diameter that constitute 80 to 90 percent of the total particles suspended in the air, is by electrostatic precipitation which has proved successful in the Layden Community High School, Franklin Park, Illinois.

Successful results in using ultra-violet radiation in elementary schools in Swarthmore, Pennsylvania was reported by Morey (35) and in Cleveland, Ohio, by Hodges (23). Wells (51) reported recent data from the

Germantown Friends School and the Swarthmore elementary-school experiments that indicated that ultra-violet radiation in classrooms reduced the spread of chickenpox, measles, and mumps to susceptible pupils. Seagers (47) described in detail the important studies of ultra-violet lighting now in progress and projected at the New York Cato-Meridian Central and Port Byron Central schools and presented the tentative conclusions reached on the basis of this experiment to date. Perkins and others (43) also reported on this experimental study. The results were promising but not conclusive, and further experimental investigation is needed to ascertain satisfactorily the effectiveness of ultra-violet irradiation and other methods to control air-borne infection in a school environment. Pleasantville, New Jersey, was reported (22) as the first community to have embarked on a three-year communitywide test of the use of ultraviolet rays to disinfect the air inhaled by school children. Yates (53) claimed that forced ventilation caused an increase in the absences of high-school pupils due to respiratory illnesses.

Factors in Body Health and Comfort

Seagers (46) pointed out that the comfort and health theory is concerned with (a) relative freedom from air-borne infections, injurious chemicals, and dust; (b) motion of air; (c) temperature; (d) humidity; (e) draft sensation; and (f) removal of odors. Nelbach (38) presented a well-organized summary of current best thought regarding standards for school heating and ventilation and suggested that the expression "thermal and atmospheric conditioning for schools" be used in place of the term "school heating and ventilation."

Gilmer (15) described the psycho-physiological principles of bodily temperature adjustment and the mechanism of the skin that operate in the perception and control of body temperature changes. Keeton (26) and Tasker (48) joined in this discussion, and called attention to earlier studies and reports of body temperature sensitivity and control. Adlam (1) maintained that the concept that warm ambient air is necessary for thermal comfort is fundamentally wrong. Rowley, Jordan, and Snyder (45) reported that variations in relative humidity from 35 to 60 percent did not cause any change in the feeling of comfort of office workers, but Leopold (32) supported the validity of the effective temperature index.

Nesbitt (39) reiterated his views regarding standards of adequate ventilation in terms of maintaining acceptable odor and effective temperature levels in classrooms, and the advantages of unit ventilation in maintaining such standards; Nesbitt (40) also maintained that heating and ventilating standards generally accepted as essential for schools can be met only by mechanical methods. Yates (53) listed disadvantages and presented data to make a case against forced ventilation.

Miscellaneous Topics and Trends

Otis (42) described the origin of the "unit" system and the progress made in its design and application. He maintained there is no need to provide special provisions for venting air from classrooms equipped with unit ventilation, and dismissed objections to corridor venting as a fire hazard. Others (19) offered objections to corridor venting. Hatch (17) presented a list of fourteen safeguards in the installation and operation of ventilating systems to eliminate fire and smoke hazards.

Clancy (9) described the heat pump, or reverse cycle refrigeration, for heating buildings in winter and cooling them in summer. Kemler (28) discussed the advantages and limitations of air, underground water, and the earth as heat sources. Tucker (50), as did Kemler (27), presented a review of the general information now available and suggested additional studies and laboratory work that are needed to permit the rational design of heat sources for reverse cycle refrigeration.

The use of heating coils to melt snow on surfaced playground areas, loading platforms, walks, and driveways seems to offer possibilities that school officials in northern climates should investigate. Krueger (30) advocated electro-thermal space heating, and Lewis (33) and the editors of *Heating and Ventilating* (21) presented their ideas of heating and ventilating systems for the school buildings of the future.

Sanitary Facilities

Cannon (8) collected the opinions of architects and schoolmen regarding the sanitary fixtures preferred for postwar schools. Corrigan (12) scored the neglect of toilet room housekeeping and supervision and lack of concern for forming good pupil handwashing habits in schools. Treanor (49) urged schools to provide adequate handwashing facilities and opportunities for pupils to use them.

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CHAPTER VIII

Trend in Materials and Design

HENRY L. BLATNER

THE past three and a half years have produced marked progress in the conception and design of the school plant. The urgent need for educational facilities, the necessity of economical planning, and an increased emphasis on function rather than tradition have all focused attention on a new and exciting design philosophy. It was quite encouraging to note the informal, friendly type of building which came into prominence at the expense of the more rigid, monumental type of structure commonly erected to serve as a school building. Great emphasis has been placed on safety, child scale, satisfactory illumination, and flexible arrangement of the component parts of the schoolhouse to permit joint use of the entire project by children and adults alike, either separately or simultaneously.

There was a marked tendency toward proper cooperation between the educator and architect to produce schoolhouses which would further the educational program of a school district rather than serve as a questionable monument to either or both of the parties involved. Such a tendency has been aided by high costs and scarcity of building materials. The ingenuity of the designer has been taxed to the utmost in order to produce adequate educational facilities for the maximum number of children within minimum budgets. Therefore, applied and extraneous decoration, excessively expensive materials, and antiquated thinking fortunately have been relegated to the past so far as most schoolhouse planning is concerned.

In the field of pure research, however, there appears to have been a paucity of sincere, scientific effort. Possibly the work of Harmon (11) represented the broadest research undertaken during this period. He continued basic studies previously begun in Texas, using 160,000 elementary-school children in the public-school system as objects of study. He and his staff paid particular attention to the matters of posture and daylighting relative to over-all bodily development. They charted the physical condition of many children over a period of years and concluded that poor posture and inadequate daylighting were major contributory factors to excessive body stress, fatigue, deformities of varying degree, and low performance standards. Twenty-four experimental centers were established in Texas for studying improvements in schoolhouse furniture, natural and artificial illumination, brightness control, and color correction. The Harmon studies were unquestionably a major contribution to the advancement of schoolhouse planning and design. One should be careful, however, not to be lulled into the belief that any one method is the correct or ultimate answer to the basic problems involved. There continues to be a wide difference of opinion among educators, architects, and scientists as to the validity of certain standards which have been established. Independent research free from commercial flavor is an urgent need.

Notable, also, was the exhaustive study made by Paul (26). His work covered natural illumination and its component problems and was based primarily on the use of prismatic glass block of certain manufacture. He approached the daylighting problem with proper emphasis on low brightness contrasts and integrated design for better illumination. Complete data concerning the natural lighting of a hypothetical classroom of defined dimension with a unilateral panel of prismatic glass block was developed and compiled. Using an artificial light source to simulate the sun in conjunction with a scale model of the hypothetical classroom, important information relative to sun angles and light intensities was recorded in efficient form. He showed that use of prismatic glass block provided a step forward in the field of natural illumination. It must be noted again, however, that this study proposed one particular method and one particular material for classroom daylighting. The data might well be employed by architects as a useful tool rather than as an accepted method without further thought or research.

Materials

The anticipated revolution and drastic change in postwar building materials did not materialize altho such a possibility was envisioned by several writers. It was discouraging to note that contemporary production technics were not applied to construction methods in general. However, such technics were applied to the manufacture of building materials and offset excessive installation costs to some extent. One significant development was the introduction of modular design. The history and development of this design was reviewed by Lorimer (19). He pointed out the possibility of lower building costs thru use of standardized integrated dimensioning and manufacture of materials and equipment. The technical problems and proposed solutions connected with modular design and coordination were illustrated by Adams and Bradley (1).

Pearson (27) traced the influence of materials of construction thruout the history of building and pointed out the liberation of architectural form thru the invention of steel. He noted new and novel materials and methods such as plastics, rustless metal alloys, prefabricated building and parts of buildings. Re-examining the use of older materials such as marble, wood, and glass, he noted that they are now being designed for mass production and broader general use rather than for the custom type of production and design used heretofore. He concluded that contemporary, functional architecture is trying to use the machine age to develop new forms and that the outstanding feature of this particular period is a growing interest in the more intelligent application of materials in order to improve our structures.

Severud (35) displayed a keen sense of the use and propriety of reinforced and architectural concrete and envisioned distinct advantages which might be expected thru the use of concrete. Higgins (15) discussed the place of steel in school-plant construction and noted several advantages to be gained thru the use of steel as a load-supporting medium. He touched lightly on the intriguing subject of the rigid frame principle of design which has direct application to all types of schoolhouse structures. Popkin (30) reported an interesting use of adobe as a structural material in a school-building program in the southwest. Plummer and Wanner (29) explained reinforced brick masonry and its application to schoolhouse construction.

Essex (9) reported considerable increase in the use of plywood, asphalt tile, and reinforced concrete but concluded that revolutionary changes in school-plant construction were not yet at hand.

Vallin (39) referred to new materials and methods but felt that they would provide better ways of achieving existing effects rather than drastically change our present concept of material and texture. Included in the discussion were breathing walls, impregnated woods and plywood, paints, lacquers, and other equipment. Creighton (7) noted the increased use of glass in varied form, particularly glass block and insulating glass, and explained the advantages and disadvantages of various types of glass.

Cannon (5) reported the results of a survey conducted among administrators and architects relative to materials preferred for use in schools. Smith (36) evaluated and charted various materials suitable for interior wall and partition surfaces. He illustrated the nice balance required of a material in order to achieve the multiple advantages of low cost, low maintenance, light reflection, acoustical benefit, and flexibility. Linn (18) made a similar study of flooring materials while Schwarz (34) assembled data on acoustical treatment.

Design

The majority of writers agreed that the desirable schoolhouse would be one designed from the inside out. All parties concerned with educational facilities seemed to agree that the trend toward objective buildings is the correct trend. Scientific planning appears to have overcome the hurdles of sentimentality and tradition. This attitude was reflected by Bursch and Reid (3) and Haskell (13) who discussed the desirability of extended architectural services to include long-range planning. Mentioning reports and surveys to cover population trends, housing trends, future sites, and transportation, they recommended that these serve as the basis for an intelligent, flexible master plan. They advocated such a plan to guide present and future schoolboards in evaluating individual schoolbuilding requirements relative to the full contemplated program. Essex (9) wrote that many have come to believe the successful school plant should be designed in a functional, informal manner to achieve the best results and that such a building is usually more economical than the traditional, formal structure. He noted that the movement from traditional to contemporary design is a west-east movement across the country.

Haskell (14) reported an advance in basic standards during 1946, the increase of one-story school designs from west to east, and the use of open corridors in areas of moderate climate. Wurderman and Becket (41) erected an example of the extended one-story type of structure so favored in the far West. Sutherland (38) argued against standardization in order to best serve student groups with varying degrees of ability and speed of learning. He noted that the true purpose of an educational system is development of the individual and that such a program demands school plants which are most flexible. Kump (17) prepared a very interesting set of sketches illustrating free planning of the modular type consisting of several buildings coordinated by means of open, covered walks and courts. While applicable primarily to moderate climate, this conception was an inspiring one and worthy of study.

Several writers were concerned lest there be insufficient thought and study on the part of each school district inasmuch as each individual program and environment differs from others. For example, Englehardt (8) stated emphatically that one of the least constructive acts is to copy the school plan of another community. He felt that contemporary design assumes safety, sanitation, and comfort as a matter of course and that only as the schoolhouse achieves the position of an inspirational and educational center can the work of planning be considered successful.

Anderson (2) pointed out the danger of patterning one school building directly from another and the danger of schoolboards' holding out for preconceived plans merely because they were successful elsewhere. He stated the oft-repeated axiom that schools must be designed from the inside out and noted the importance of organic design which relates building to site culturally as well as architecturally. He contended that a school plant reflecting utilitarian values, artistic proportions without extravagance, and an understanding of the immediate locale would be a great stimulus to the culture of an entire community. He also noted that the architect has an exceptional opportunity to create an environment when designing a new school building.

Nichols (25) cautioned against any particular style of building as such. He compared the archeological, romantic approach which he considered lifeless with the self-conscious modern approach which often might be insincere or the desire for just something new. It is doubtful, however, that this comparison indicated a full understanding of the friendly, selfless type of building which most informed people preferred. In his observations was sensed a hesitancy in breaking with the past, a reluctance to clear the way for intelligent, uninhibited planning.

Vincent (40) explored the problem of functional school building and noted twelve basic considerations of school planning.

Multiple Use and Expansion

Great stress was laid upon the design of school buildings for multiple use. Essex (9) indicated the trend toward joint school and community planning and observed that few additional facilities were needed beyond the usual ones in order to fulfil joint requirements.

Clapp and Perkins (6) summarized the reasons for and problems involved in planning for multiple use of school-plant facilities. Matson and Matson (21) described the stirring possibilities of an educational program which might be attained when proper meeting of the minds of educator, social worker, and architect is reached. They envisioned the extension of the educational facilities of a community to include those of neighboring communities, thus providing for exchange of ideas, broadening of horizons, and new friends.

Smith (37) discussed the necessity of flexibility and provision for expansion in the school plant. He believed these factors of prime importance due to the establishment of higher and more definite standards in every area of education, the increase in importance of the elementary, vocational, and agricultural type of school building, and the increased adult use of school buildings. Melby (22) pointed out educational requirements while Haskell (12) illustrated several solutions for these requirements. Both stressed the desirability of functional, multi-use planning.

Design Factors

It is interesting and important to note the effect on school design which may be attributed directly to a careful consideration of lighting. In addition to the research efforts of Harmon (11) and Paul (26), there were found studies indicating differences of opinion on the basic premise of whether or not daylight is the ideal source of schoolroom illumination.

Kaelber and Waasdorp, Wheeler and Will (16) presented an interesting study which compiled the average and probable number of "sun hours" in four widely separated American cities. Using their findings, they illustrated plans and sketches for a school building wholly dependent on an artificial source of classroom illumination.

Wynkoop (42) contradicted the use of artificial light as the main source of illumination. He illustrated the direct effect on school-plant design and appearance which results automatically from an intelligent consideration of natural light source.

Lyndon (20) achieved a noteworthy child scale and a pleasing atmosphere in his sketches and proposals for a California school. It is indicative that such a result grew from original thinking based primarily on a well-conceived method of daylighting. A comparison of this study with the work of Rich and Conn (32) illustrated two extremes in the contemporary approach to and appearance of buildings published concurrently.

An equally important design factor is the question of one-story versus multi-story school buildings. There was noted a definite trend toward one-story buildings by observing both recently completed and proposed structures. Arguments in favor of one-story buildings were safety, better natural lighting possibilities, child scale, and economy thru use of nonfireproof construction. Arguments in favor of multi-story construction were based mainly on economy of land and construction.

Cannon (4) noted as the result of a survey conducted among architects and educators a preference for two-story, basementless buildings. Fawcett (10) described and illustrated a well-conceived, open plan type of one-story building based on a thoro survey of the needs of an entire community. It is questionable whether or not the clear thinking applied to the building program was compromised by the exterior appearance.

Priaulx (31) illustrated a sprawling, one-story school plant. Saarinen and Swanson (33) achieved a well-organized, friendly one-story building. Yet Pence (28) described a new two-story high-school building which received an unusual amount of thought so far as program requirements and site planning were concerned.

In the opinion of Miller (24) school districts with semipermanent structures (which infers one-story) will have less hesitancy in following new trends than those districts with more permanent and costly buildings. Melendy (23) emphasized strong reasons for large, square classrooms which are more adaptable to one-story structures.

All in all, there seemed to be no definite proof of the superiority of one-story or two-story schoolhouses. It might be stated, however, that the general trend is toward the one-story school plant wherever feasible.

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CHAPTER IX

School-Plant Operation, Maintenance, and Insurance

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In the February 1945 Review of Educational Research school-plant operation and insurance were discussed in separate chapters. The school-plant maintenance review was unavoidably omitted from that issue. This issue covers maintenance, operation, and insurance in one chapter. The section on maintenance includes a report of some studies on school-plant modernization and, to compensate for the maintenance chapters omitted from the 1945 issue, some maintenance studies completed prior to that date. The section on insurance includes a review of reported information in the closely related fields of fire hazards and fire prevention.

School-Plant Operation

During the war years greater use of the school plant increased the operating load. At the same time operating supplies were limited and many of the more able custodians and engineers were lost to the armed forces or to better paid jobs. Due to these and other causes, operating standards were lowered and the many administrative problems connected with plant operation programs increased in number and scope. These problems have been freely discussed but there has been only a limited amount of experimentation or research reported that would help the school administrator solve his operating problems. Even as late as the end of the year 1947 many administrators had not yet been able to rebuild competent custodial staffs or to overcome the effects of the poor operating practices of the war years.

Organization of Program

Various methods have been used to improve the morale of the custodial force and to develop a better working organization. Knoll (62) reported that improved personnel policies, such as the establishment of a merit plan with sick leave, vacation time, and employee retirement, paid big dividends. George (34) found a local custodial employee committee helpful in establishing policies, developing training procedures, and improving morale. Chipman (14) and Stoy (109) pointed out the importance of selection and training as factors in developing a competent custodial force. Cruickshank (20) indicated that one of the purposes of the Ohio Association of School Employees was the improvement of service to the schools. *School Life* (89) in a summary of school costs for the 1943-44 school year showed that for seventy-four small towns the plant operating costs averaged $13.12 per pupil in average daily attendance. This was about 12 percent of the average total cost per pupil. In these cities the operating costs ranged from 6 to 17 percent of the total costs per pupil.

Work Standards

There is a recognized need for better working conditions and improved work standards. The *School Executive* (86) outlined a suggested housekeeping checklist as one measure of operating efficiency. The Los Angeles Schools (66) developed in some detail a set of instructions and suggestions on housekeeping practices and procedures for various parts and areas of the building. Linn (65) listed careful selection, training, good supervision, and adequate tools and equipment as vital factors in economical custodial services. The Milwaukee Bureau of Plant Operation (72) outlined the essential steps in maintaining safe buildings and working conditions. To improve the New York City custodial service, Hynds (48) recommended a supervisory program, a reporting system, custodial ratings, inservice training, specific assignments, and cooperative committees.

The often-mentioned but still unsolved problem of work loads as factors in efficient and economical custodial service again received attention. From a survey of custodial services and plant operations, Smith (106) found a wide range of work loads. He listed building age and the type of fuel as two of the principal factors in determining work loads. He advised using square feet of floor space per minute as a unit of work load measurement. Huggett (44) reported less specialization, less supervision, and less standardization for custodial service in small towns. He recommended a daily schedule for each employee. Steen (108) reported satisfactory results with a work load schedule based on room cleaning equivalents. Thompson (112) reported that work loads were computed on various bases such as enrolments, number of rooms, and floor areas. She found that for the custodian work loads studied, 26 percent required a twelve-hour day, 39 percent a fifty-hour week. Sixty-five percent reported no definite work schedules.

Knoll (63) reported that with desirable incentives such as security, adequate wage scales, and suitable working conditions the morale of employees improved and fewer were lost to outside employment. Hynds (49) recommended the development of a plan for evaluating and recognizing custodial efficiency. He reported that with improved services the New York City school fuel bill was materially reduced. Daniels (21) stated that trained employees had been able to make a 50 percent reduction in certain repair costs.

Personnel Problems

When schools opened for the 1947-48 school year the *Nation's Schools* (76) reported some salary increases and more custodians available for employment. O'Keefe (78) stated in 1945 that only ten states or about 12 percent of the nonteaching school employees enjoyed the benefit of retirement laws. Both O'Keefe (78) and Clifford (16) felt that retirement systems should be extended to cover the nonteaching employees. The lack of reported studies on the unionization of operating employees seemed significant. However, the *American School Board Journal* (3, 4) indicated that legal opinion generally is to the effect that unions of public employees have no status that might limit the authority of public bodies. It offered the opinion that boards of education are under no compulsion to recognize unions. It also stated that there is yet no one accepted policy covering schoolboard and employee union relationships.

Altho the need for trained custodians is pressing, many custodians still have no opportunity and little encouragement to participate in directed custodial training programs. Seagers (95) and Stoy (110) pointed out that custodial service in modern school buildings requires technical knowledge and skills that can best be developed with well-planned training programs. Various methods have been used in custodial training programs. Metcalfe (70) and the Industrial Sanitation Research Foundation (50) described the use of films and other visual aids as training media. Various training methods, including apprenticeship training, occasional classes, printed instructions, and schools organized with sequential courses leading to certification, were reported. Some of these schools were local and some were organized on a statewide basis. Putnam (80) stated that the school business managers should accept the responsibility for promoting and organizing custodial training programs. The Milwaukee (73) school officials developed an inservice program that combined printed instructions, class study, and supervisory advice on all phases of plant care, protection, and safety. Holubowicz (43) reported specific savings resulting from these programs. Sessions (97) reported a shortage of trained personnel and indicated that a legal opinion of the state's attorney general permits Ohio boards of education to pay the expenses of custodians attending training schools. Connecticut is one of the few states offering a statewide custodial program and Crouse (19) reported that the schools were set up for seventy-five hours of class instruction. The courses covered a wide range of subjects and completion led to a diploma. Kansas has one of the oldest, continuous, statewide training programs in the country. Winkel and Parker (127) reported that the effects of the programs were reflected in improved building care in the state's schools and in better morale of the custodial forces. Their report covered thirty-five janitor-engineer schools over a period of seventeen years with an aggregate attendance of over 3700.

Operating Procedures

The many reports made on operating procedures indicated a recognition of their importance, and of the problems involved. However, the lack of agreement on methods indicated a need for more research on plant operating procedures. Von Tungeln (122) pointed out the importance of floor sanitation in health protection, and Graban (38) stated that damp sweeping makes for cleaner floors. Smalley (98, 99, 100, 101) warned against the use of oils on composition floors; advised the use of door mats to protect floor surfaces; stated that special attention must be given to the protection of waxed floors in winter time, and asserted that a proper base is essential before applying a surfacing material on concrete floors. Welch (124) recommended the use of tow mats in removing rubber burns. Barbour (10) concluded that custodians must know the principles of, and methods to be used in, floor care.

Some attention was given to operating practices in other areas. Whitaker (126) found that the promiscuous use of boiler compounds may be harmful to the heating system. Harris (39) urged use of the electro static process for cleaning the air in school buildings. Seagers (96) described various sanitary supplies needed in plant operation, while Hess (41) recommended a vermin eradication program, and Weed (123) found DDT valuable as an insecticide. George (35) reported that the life of window shades would be prolonged by trimming and rehanging. Kerrick (59) found that increased light and the removal of the sources of odors improved toilet sanitation. Bisel (12) urged that custodians give more attention to safety, and Milne (71) outlined recommended work procedures for the operating personnel. Kacel (58) stated that in industrial sanitation the first aim was to prevent the accumulation of dirt. He found that research in plant sanitation had been neglected. The Industrial Sanitation Research Foundation (51) prepared a worker's manual on sanitation and cleaning procedures.

School-Plant Maintenance

Planning the Maintenance Program

In too many cases maintenance neglect has led to rapid deterioration of the buildings. Viles (118) stated that maintenance programs should be planned on a scheduled basis, that the anticipated costs should be included in the annual budget, and that the custodians should be trained in maintenance procedures. Clark (15) found that maintenance tasks could be classed as major nonrecurring, urgent recurring, and recurring nonurgent. He recommended long-term budgeting for maintenance. Adequate financing and preventive maintenance on a scheduled basis was recommended by McGrath (68). Husband (45) discussed the value of a schedule in maintenance. Du Frain and McGrath (23) pointed out the difficulties in wartime maintenance, and *School Management* (91) summarized a forty-one point summer maintenance program for one city.

School Life (89) reported that for 1943-44 the average maintenance costs were four dollars per pupil in average daily attendance in the schools of seventy-four small cities. This was a little less than 4 percent of the total average cost per pupil. The annual maintenance costs ranged from less than fifty cents to nearly twenty-eight dollars per pupil, or in percent terms from ½ of 1 percent to more than 18 percent of the total average cost per pupil. Preventive maintenance and an ample budget allowance were recommended by Johnson (53, 55). He recommended the development of an adequate maintenance shop, well-equipped and well-manned. Saunders (83) proposed weekly inspections of all buildings, current repairs as needed, with more extensive summer programs. George (33) pointed out the importance of complete current inventories as a factor in total property upkeep. *School Management* (92) reported excellent results in a California high school from a student's maintenance committee organized to aid in plant preservation.

Engelhardt (26) reported reduction in the incidence of disease and improved attendance resulting from air sterilization of school buildings. However, he made no recommendations pending further experimentation in this area. Gallistel and Peterson (31) advised complete heating repairs during the summer. They recommended that all ducts and tunnels be cleaned. Schmidt (84) stated that poor maintenance leads to lowered efficiency for heating, ventilating, and lighting systems. Raddar (81) found that nine out of ten schools could reduce costs and improve heating services by proper maintenance of radiator traps, checking vents, repairing the chimneys, and by the general overhauling of the whole heating system. Frostic (30) recommended that furnace rooms be cleaned up and then painted so that they may be more easily maintained. McCarty (67) outlined certain procedures in maintaining toilet rooms.

Maintenance and Rehabilitation

While modernization and rehabilitation may be classified as capital outlay or remodeling programs their relationship to current maintenance justifies the inclusion here of recent studies and reports on plant rehabilitation. Since most schools cannot erect now all of the new facilities desired there is reason to give attention to maintenance and rehabilitation needs and possibilities.

Viles (116) reported from a study of 327 buildings that 150 needed major heating plant improvements, and that 130 needed improvements in the ventilating system. He found lighting and plumbing facilities in a majority of the buildings in need of repair or replacement. Exit facilities also needed to be improved. He also set up an eight-point criteria to help solve the problem of when to abandon or when to remodel a building. Kierman (60) advised that existing buildings be re-examined to determine whether they might be retained in use if rehabilitated and properly maintained. Hauser (40) pointed out that lighting facilities, plumbing, decoration, and fire-safety features deteriorate rapidly and need frequent attention. Starin (107) listed mechanical systems repairs as factors in a remodeling program. The *American School Board Journal* (6) stated that it is desirable to make essential repairs even if the new construction program must be delayed. *Nation's Schools* (77) listed various repairs and improvements necessary to improve safety conditions in the buildings. Schwarz (94), Best (11), and McMurry (69) discussed methods of obtaining better sound control in the buildings. Irons (52) reported that life, health safety, and functional adequacy were used as criteria for evaluating old buildings. The *Elementary School Journal* (25) stated that because of heavy wartime use of school plants the federal government should now help finance the repair and rehabilitation programs.

Maintenance of Sites

The improvement of school playground surfaces continued to receive much attention. Schotland (93) in reporting on the results of several years of experimentation with gravel, sod, crushed stone, concrete, and other methods of playground surfacing stated that he had found asphalt-cork and hot asphalt on dirt best suited to his needs. Fetherston (28) reported that cold asphalt and dirt mixtures were providing acceptable and economical playground surfaces. Hoek (42) also reported good results with asphalt surfacing. Lentz (64) described lawn maintenance procedures. Viles (117) reported that proper maintenance improved safety conditions on the playground. Bailey (9) outlined a cooperative school and community plan for the maintenance of grounds.

There was much interest in the rejuvenation and maintenance of floors. Glanzer (37) reported that a new impregnation process adapts soft woods for floor use. Smalley (102, 103, 104, 105) reported that wax substitutes have not proved satisfactory and outlined methods for refinishing old oiled floors, for the removal of rubber burns, and for summer floor rejuvenation. The *School Executive* (88) stated that asphalt tile floors should be waxed at least three times a year.

There were a limited number of studies reported on other maintenance needs and procedures. The *American School Board Journal* (7) described the need for and procedures to be used in waterproofing certain types of walls. Welch (124) outlined roof repair procedures. Corbitt (18) found preventive maintenance for school equipment economical, and Telford (111) reported that adequate maintenance materially improved safety conditions in the school. Townsend (114) reported satisfying results from an experiment with a multiple color scheme for classrooms. Browne (13) outlined criteria for paint selection. *Hygeia* (47) recommended changes in the care of room lighting, and Allphin (2) found that regular maintenance reduced current cost and increased lighting efficiency.

Property Insurance

Research on insurance practices in the 1945-1948 period was limited. However, building values continued to increase and insurance undercoverage was common. The *School Executive* (87) reported that coverage was far below current insurable values. Joyner (56, 57) reported that increasing values created a demand for more coverage and developed a seller's market for insurance. He also reported much undercoverage and recommended that school officials develop and maintain current evaluations for all property to be protected by insurance. Pattington (79) stated that while self-insurance may be feasible for large districts it is not practical for the smaller school districts. Garvey (32) described the procedures followed in establishing a continuing insurance program for Oak Park, Illinois. The *American School Board Journal* (5) found that better school-plant management and possible rate reductions would aid in decreasing insurance costs. It recommended six major areas in which improvements are needed in the local insurance program. Viles (120) reported that insurance costs could be reduced as much as 30 percent on nonfire-resistive and about 75 percent on fire-resistive buildings by use of co-insurance contracts. He recommended that insurable values be computed as current replacement costs, less depreciation, less allowable exclusions.

Fire losses and fire prevention are closely related to property insurance and in these areas there was more activity. The outstanding activity in this field was The President's Fire Prevention Conference in 1947 which brought together about 2000 of the nation's leading authorities in insurance and fire protection. The report of the Committee on Fire Prevention Education (29) stressed the obligation of all school officials and employees to help maintain fire-safe conditions in the schools. It recommended state department of education participation and leadership in maintaining fire safety in school buildings. Colt (17) recommended sprinkler systems for school buildings. Hutson (46) found 2 percent of fires were responsible for 70 percent of property loss. Kimball (61) reported an increasing frequency of school fires. He cited electrical hazards, smoking, incendiarism, and heating equipment as the most common causes of school fires. *School Management* (90) listed similar hazards, and the National Fire Protection Association (75) reported a total loss of 807 lives since 1908 in school fires.

Viles (119, 120) stated that the continued presence of fire hazards in a school building denotes inexcusable ignorance or carelessness. He pointed out numerous structural and operational hazards that should be corrected. He urged that more attention be given to evacuation procedures. Essex (27) stated that masonry walls do not make a fire-proof building. He listed fire prevention, checking and spread of fires, and evacuation as protective measures. The Safety Research Institute (82) listed the principal sources of information on fire safety. Easton (24) and Downs (22) recommended the installation of fire doors and sprinkler systems and Bacon (8) pointed out the importance of having the right type of fire extinguishers. The Milwaukee Public Schools (74) have prepared and are using a detailed inspection form in checking school fire safety.

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CHAPTER X

Financing the School Plant

WILLIAM R. FLESHER

The importance of money in the development of school-building programs has become increasingly evident in the issues dealing with school plant in the last five cycles of the REVIEW OF EDUCATIONAL RESEARCH. The organization of material regarding this aspect of the school plant in the present issue follows quite closely that followed in the fifth cycle (13).

The triennium since 1944 has seen relatively little actual research in the area of financing school-plant construction. The period has been characterized, however, by a great amount of planning for future construction. This is a healthful emphasis in that careful, long-range planning tends toward wiser expenditure of money. There seems also to be a developing trend in the use by boards of education and superintendents of schools of the services of outside consultants in the field of school-plant planning. School staffs generally cooperate in this procedure.

There appear to be other developments with certain financial implications in school-building planning. School-survey services are being inaugurated by several state universities and teachers colleges. The institutions already providing this type of service have had increasing numbers of calls for survey work, particularly in the field of school buildings. Flesher (12) indicated the growing demand for the services of one such agency.

The period of economic prosperity during and following World War II has induced school districts to seek approval of many bond issues for capital outlay. Prevailing low-interest rates have been conducive to this activity. Existing high building costs have led many school districts, on the other hand, to be hesitant in asking for bids and in letting contracts. Many districts which have secured approval of bond issues have sold their bonds to take advantage of low-interest rates and have invested the money in some type of short-term investment, awaiting the day when a reduction in building costs will make it possible for them to go ahead with construction within their financial limits.

Many school districts are hopefully expecting some type of federal aid for new school plants. Some writers, Thurston (29), for example, in the field of school and government finance predict, however, that federal aid of this kind will be made available only in case of general unemployment.

School-Building Needs

Estimates of the backlog of needed school-building construction continued to vary appreciably but in all cases were relatively large. Hamon (14) pointed out that the per-pupil value of existing public-school plants ranges from $103 to $670 among the different states, with a national average of $371. He concluded that an over-all school-plant value of $500 per pupil should constitute a minimum goal in the postwar era, or an increase of $129 per pupil above the present average. To raise the school-plant value to the level of $500 per pupil would require $3.2 billions. On the same per-pupil basis an additional $2.5 billions would be required to provide adequate housing for the five million children of school age who are not in school. Hamon estimated further that only about $800 million would be spent from 1941 to 1947 and that from 1948 thru 1952 $2.4 billion will need to be expended to bring the school-plant value to a $500 average per pupil for those children now in school.

Thurston (29) in 1947 estimated a national need for approximately $6 billion for school plants and an additional $2 billion to make our school buildings "absolutely safe" and "places of comfortable and efficient habitation."

Lewis (19) estimated a need of $2.5 billion for the five-year period following the end of the war. On the basis of a questionnaire study made in 1944 by the American Association of School Administrators, Cocking (8) estimated the cost to meet the public-school building needs of the nation to be approximately $2 billion, exclusive of rural and consolidated school districts, where the need is probably greatest.

Efforts to meet school-plant needs have not been lacking. Table I, compiled by the writer from *Bruce's School Market Letter* (3), presents certain data relative to the extent of building contracts let from 1944 thru 1946 and the school bond sales during the same period.

TABLE I.—SCHOOL BONDS SOLD AND SCHOOL-BUILDING CONTRACTS LET, 1944 THRU 1946

Year	School bond sales	Contracts let		
		Number of projects	Square feet	Value
1944	$ 51,224,600	3,305	11,080,000	$ 72,683,000
1945	131,369,940	2,209	13,753,000	112,347,000
1946	264,182,810	2,234	25,609,000	212,729,000

Building Cost Indexes

Williams (30) computed the 1945 building-cost index for the New York area to be 157.1 on the basis of the 1926-1929 average of 100. Using the average for 1935-1939 as the base, Clark (7) computed the index for February 1947, as 165. He pointed out that since 1939 the cost of school-building materials and labor had risen 65 percent, whereas construction costs had increased 105 percent.

The *Architectural Record* (1) computed percents of increase in construction-cost indexes as of October 1947, for four metropolitan areas in the nation. The percents are as follows and represent increases since 1939:

City	*Percent*
Atlanta	73.5
New York	67.1
St. Louis	61.9
San Francisco	61.4

The above figures were prepared by the F. W. Dodge Corporation from data compiled by E. H. Boeckh and Associates, Incorporated.

Essex (11) compared school-building costs of fifty years ago with current costs. He estimated that for identical communities the volume of a school building was now four times as great as a half century ago. He estimated further that in 1945 a new building would cost ten times as much as a similar building did in 1895.

Bartels (2) computed for the city of Cincinnati indexes of total cost of construction which reflected not only the cost of construction but also interest payments on bonds issued to pay for such construction. Altho the data are local, the technic employed is valuable. The formula used by Bartels is: Index of total cost=Index of construction cost x (1 + interest rate per unit period x number of interest periods + 1.) He found that from 1921 to March 1947, the index of construction cost rose 74 percent, whereas the index of total cost rose only 19 percent. This difference is a reflection of decreasing interest rates which have tended to offset increases in construction costs. Bartels's data showed an increase of 90 percent for construction cost from a low in 1932 to a high in 1946 and an increase of only 55 percent in the index of total cost of construction (including interest) for the same period.

Division of Costs

Rosenstengel (27) gave the following as approximate divisions among the four major cost categories in school-building construction: general construction, 80 percent; heating and ventilating, 10 percent; plumbing, 6 percent; electrical work, 4 percent. Engelhardt (10) gave the following as the averages for eleven school-building projects in New York City: general construction, 77 percent; heating and ventilating, 12 percent; plumbing and drainage, 5 percent; electrical and fixtures, 6 percent. The latter figures are essentially the same as those found by Coons and Essex (9) in their analysis of the construction costs of 124 buildings.

Engelhardt (10) compared 1940 cost estimates for eleven projects in

New York City (five additions and six new structures) with low bids for these projects in 1946-47. The average percents of the excess of bids over estimates are:

General Construction	105
Heating and ventilating	80
Electrical and fixtures	75
Plumbing and drainage	54

Methods of Financing

The sale of school bonds continued to be the major source of revenue for the construction of school buildings. Since 1944 the sale of bonds has increased rapidly (*see* Table I). The amount of bonds sold in 1945 was an increase of 156 percent over the total in 1944. In 1946 the amount was approximately double that sold in 1945. Mulford (21) offered helpful suggestions regarding the issuance of school bonds for capital outlay.

Clark (6) pointed out that interest rates had declined from 1929 to 1946; but that in 1947 they had started to rise as indicated by a net average rate in July 1947, of 2.61 percent and a net average of 2.77 in August 1947. Thurston (28) pointed out the inequities existing between the assessed valuation and the real value of taxable property thruout the nation. He stated that in 1938 the estimated value of property in the United States was approximately $310 billion, whereas the assessed value was approximately $140 billion. He also emphasized the fact that altho national income had increased phenomenally, the assessed value of taxable property had not begun to keep pace but had, in fact, actually declined in many instances.

Peterson (24) and Rosenfield (26) emphasized the deleterious effects of legal restrictions imposed in most states with respect to financing capital outlay and particularly regarding the creation of school-building reserves.

Rosenstengel (27) suggested the following as a plan in budgeting for school-plant improvement: cost of bond issue, 1 percent; survey and consultants, 1 percent; site, 10 percent; selection of architect, .3 percent; architect's fees, 6 percent; building construction, 65.4 percent; educational equipment, 7.3 percent; landscaping, 7 percent; miscellaneous, 2 percent. Hamon (15) proposed the following as a budget of expenditures: land and site improvement, 10 percent; professional services, 5 percent; furniture, 10 percent; general construction, 55 percent; heating and ventilating, 12 percent; plumbing, 4 percent; electrical work, 4 percent.

State and Federal Aid

Lewis (19) suggested that school buildings be financed jointly by local, state, and federal money, the money to be divided as follows: federal, 50 percent; state, 25 percent; local, 25 percent. He supported the high percent of federal support by the statement that the federal government had pre-empted the best sources of revenue. Lindman (20) suggested the following formula for apportioning aid in the state of Washington:

$$\text{Percent state aid} = \frac{200{,}000 \times \text{number of classroom units} - \text{valuation}}{200{,}000 \times \text{number of classroom units} + \text{valuation}}$$

He pointed out that this formula combines the principle of equalization with the principle of matching. In terms of the formula the state would provide, on an average, 40 percent of the cost of construction. The range of state aid would be from 25 percent for a valuation of $120,000 per classroom unit to 73.9 percent for a valuation of $30,000 per classroom unit. Hamon (15), Johns (18), and Clapp (5) stressed the necessity for equalization in state and federal aid for capital outlay. Johns (18) pointed out that matching and flat grants per pupil were generally unsound bases. Hamon (16) stated that as of December 1945, only the following sixteen states had provided state funds for school-plant construction: Alabama, Connecticut, Delaware, Georgia, Minnesota, Missouri, New York, North Carolina, Ohio, Oklahoma, Rhode Island, South Dakota, Utah, Vermont, Virginia, and Washington.

Cate (4) reported that thru June 1942, school plants constructed under the WPA cost approximately $448 million, of which the federal government provided $314 million. Under PWA during the same period school-building construction amounted to $1,179,000, of which 45 percent was federal funds. He reported also that $142 million had been expended under the Lanham (Community Facilities) Act, with the federal government providing $66 million.

On the basis of a questionnaire survey, Hewes (17) reported data concerning school-building planning and the aid given by the federal government in this planning. Details are shown in Table II.

TABLE II.—PLANNING FOR NEW SCHOOL-PLANT CONSTRUCTION

Category	Projects	
	Number	Estimated cost
Federal planning advances approved	1,793	$ 359,513,000
Application for federal advances under review	1,034	272,242,000
Plans completed without federal assistance	1,278	276,217,000
Plans in design stage without federal assistance	2,486	891,253,000
Total	6,591	$1,799,225,000

Bruce's School Market Letter (3) presented a compilation in January 1947, regarding FWA funds for school-building planning since June 1946. The results are shown in Table III.

TABLE III.—FWA ADVANCES FOR SCHOOL-BUILDING PLANNING SINCE JUNE 1946

Type of building	Federal advance	Number of school projects	Estimated cost
Elementary schools	$1,125,803	207	$ 32,096,418
High schools and junior high schools	2,208,233	193	70,577,705
Colleges and universities	264,456	20	8,240,807
Stadiums, athletic fields, and swimming pools	47,200	9	1,034,947
Teachers' residences	2,040	3	55,083
Combination grade-high schools	16,500	4	468,530
Consolidated schools	46,600	4	1,275,436
Total	$3,710,832	440	$113,738,926

Publicity for School Financial Support

Since 1944 at least three publications dealing with school campaigns for financial support have come to the writer's attention. Of the three, Reeder (25) provided the most extensive treatment. The other two documents published by the National School Service Institute (22) and the Ohio Education Association (23) are primarily manuals for conducting publicity campaigns. Each presented much illustrative material. The value of continuous school publicity continued to be stressed by writers in this field.

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FOREWORD

THIS is the first issue of the REVIEW to appear under the direction of the newly appointed editors. The highly efficient editorial program administered by J. Cayce Morrison, formerly chairman of the editorial board, and by the associate editor, Arnold E. Joyal, has been interrupted by the decision of these gentlemen that five years of planning and editing the REVIEW is a sufficient term of service. They are deserving of the sincere thanks of the Association and of all educators for their work on the outstanding numbers which have appeared under their active editorship.

The chairman of the Editorial Board will follow the lead of his predecessors in organizing and advising with committees engaged in summarizing and interpreting the research in the fields designated in the publication schedule. There will be general adherence to all policies formulated by the Board. With the approval of the Board an assistant editor, Albert N. Hieronymus, has been appointed to handle many of the details of preparing the manuscripts for the printer. As previously, thru correspondence and in annual or called meetings, the Editorial Board formulates policies, approves membership of reviewing committees, plans and approves the schedule of topics and fields for review in each three-year cycle.

The change in editorship will in no way modify the principles which determine the usefulness of the REVIEW. The REVIEW is looked upon as a continuous supplement to the history of education. It is a primary tool for research workers, teachers, and administrators. As such it must be up to date, critical, and factually correct. The purpose of the REVIEW will continue to be to select, summarize, synthesize, interpret, and evaluate current research in education and in related fields, and to present an integrated, useful report, organized by areas of research and practical interest.

The high standards set by our predecessors on the Editorial Board will be difficult to maintain. It will be impossible without the complete and continuous cooperation of the entire membership of the Association. Please bring to our attention research which might otherwise escape the consideration of committees and contributors. Your suggestions for the improvement of the REVIEW will receive the most careful consideration.

This issue represents the seventh number dealing specifically or in closely related manner with problems of the curriculum since the appearance of Number 1, Volume 1, "The Curriculum," in January 1931. It should bring us up to date on the important thought and practices affecting curriculum construction.

HARRY A. GREENE
Chairman of the Editorial Board

INTRODUCTION

This issue of the Review covers research in the curriculum for the calendar years 1945, 1946, and 1947. The last two previous issues of the Review concerned mainly with the curriculum were the June numbers of 1942 and 1945 (Volume 12, Number 3; Volume 15, Number 3) entitled "General Aspects of Instruction: Learning, Teaching, and the Curriculum." The statement of the title of this issue, "The Curriculum: Learning and Teaching," was chosen in an attempt to highlight the essential curriculum problems of philosophical foundations, content, methods, and materials as related to the general problems of instruction.

Originally the present issue was organized in four sections:

Curriculum: Foundations
Curriculum: Status and Description
Curriculum: Methods and Materials
Curriculum: Change and improvement

As the work of the committee progressed, it seemed desirable to divide the third section into two chapters, one dealing with early childhood education (thru Grade VI), and the other with the upper-grade levels. Later a discussion of library resources was added as a final chapter.

An examination of the research covered by the period of this issue makes it clear that the war and its aftermath resulted in the interruption of the research activities of many individuals and institutions. At the same time there is evidence that the war stimulated new interests in instructional equipment and technics which have great value to educators in general, and which on that account must be evaluated here for their contributions to the curriculum. The critical directness of a nation at war resulted in giving serious attention to the need for curriculum planning and to the processes of curriculum change. There is extensive research on these phases of curriculum. Obtaining needed curriculum improvement is largely a matter of motivation and group dynamics. Curriculum workers are beginning to review the research in these related areas. The research for 1945-1947 also discloses the presence and influence of new curriculum emphases and content such as aviation education, intercultural programs, and mental hygiene.

Studies in special curriculum areas are not included in this issue unless such research has general implications. Other issues of the Review are planned to cover the research in certain of the individual subject fields.

William E. Young
Chairman

CHAPTER I

Curriculum: Foundations

WILLIAM H. BRISTOW

Modern curriculum foundations rest on the synthesis of many disciplines. An adequate treatment of foundations therefore would be broad in scope. It would rest heavily upon the research reported in former issues of the Review, especially those dealing with such factors as growth and development, citizenship education, and social foundations. This chapter summarizes merely the pertinent research and some of the general literature to show trends and highlight important developments in the field of the curriculum during the calendar years 1945-1947. Many of the studies reported here are comprehensive in scope, synthesizing philosophical, sociological, and psychological concepts which must underlie any consideration of curriculum foundations. Others, it is believed, are sufficiently specific to indicate clearly the philosophy and scientific background of curriculum research and revision.

Rugg (39) undertook a synthesis of key concepts in the four foundations of American education which he delineates as: new biopsychology—the study of man, his nature, and behavior; new sociology—an emerging science of society and culture; new esthetics—the study of man's expression and appreciation; new ethics—the emerging moral codes and the formulation of first principles of ethical conduct for the industrial society. Rugg maintained that modern creative thought could assemble and organize a program to guide youth and to develop an education to serve modern man. Knowledge of the culture is sufficiently clear to design the content of such an education. Man and his behavior are sufficiently known to organize its teaching. Expressive experience has been lived to insure a high order of esthetics. The first principles of conduct are sufficiently clear to solve the problem of freedom and control. These foundations provide the makings of a great education but they have never been organized in a way to be focused directly on the problems of man. Counts (13) suggested that education is a most important factor in achieving social democracy.

Altho limiting themselves more sharply than Rugg, two authors writing during the period sought to reassess educational plans and traditions. Butts (6) covered the span of history from primitive times; Edwards and Richey (16) devoted their efforts to America. Both are concerned with education and the culture, and the recognition of education as a social force.

Dewey (14) pointed out that altho scientific methods influence the economic conditions under which men live, they do not do much to determine the moral, the humane, ends served by engrossing practical conditions, the actual state of ends and values. The social subjects today are in much the same state as physical subjects three hundred years ago. Dewey further recommended the use of the same kind of systematic and comprehensive criticism of current methods and habits which a few hundred years ago set going the revolution in the field of physical knowledge.

The crisis in American Education and the democratic values, which must prevail if education in our time is to make itself felt for good, were well described in a number of the *Survey Graphic* (3). Special emphasis was placed on the problems which must be met if freedom is to be maintained. The effects of different ideologies on thought control, as well as on all aspects of life, were presented in two House Documents; one on communism (19) and another on Fascism (20). Emphases in instruction under communism were reported as follows: "Soviet education emphasizes love of country, the glorification of Russia in history, science, the equality of peoples, socialism, and military power. The entire educational program expresses Soviet domestic and foreign policy and is directed toward the goal of overtaking and surpassing 'the most advanced capitalistic countries'" (19:116). The American emphasis on individual instruction and freedom of teaching was contrasted sharply with Soviet emphasis on a unified system and indoctrination in communism. Fascism was represented as a psychological, not a rational force: "It is built upon the support of the masses as they are directed under a system of führership. The philosophy is one of faith, belief, regulation, uniformity, and constraint. Fascist thought is national-mindedness to the *nth* degree based on a political foundation. Its sole consideration is the success and survival of the fascist state, to that end everything must be surrendered—objectivity, logic, consistency, and even truth itself" (20:35).

Hook (23) concluded that the fundamental problem of our culture is to defend and extend the democratic heritage of rights and freedoms in an industrial economy that can provide security for all. This security, on a plane commensurate with human dignity, has not been achieved in an unplanned economy nor has it been achieved in a planned economy under a dictatorship. Even tho political freedom without economic security is defective and precarious, economic security without political democracy is impossible.

The President's Committee on Civil Rights (36) documented the ways in which the fundamental principles of human rights are being achieved, treated the progress made, and the difficulties and problems confronting contemporary society which must be faced if the ideals expressed in our great documents are to be made a reality for all people.

A report of the Educational Policies Commission on elementary education (31) pointed out that both good and efficient schools are needed. Good schools rest on values that are good. Efficient schools should promote these values. Hitler's schools were efficient, but not good in terms of American values. Another Educational Policies Commission report (32), first issued in three separate sections, should be mentioned here since it brings together significant material coordinated as one study.

Many educators have had an opportunity to view first-hand the effect of other ideologies upon the life and character of other people. While concerned that democracy shall have an opportunity to serve thruout the world, there is equal concern that American education and policy, which is the beneficiary of a forward-looking social system, shall operate to remove the stresses which are threats to democracy itself. Strebel (43) proposed a nationwide program of community and educational planning which will transcend the four walls of the school and attract basic values of men in the interest of greater social democracy.

In reviewing world trends Toynbee (45) pointed out that there is a tendency toward standardization and uniformity. This tendency is the correlative and opposite of the tendency toward differentiation and diversity which has been found to be the mark of the growth stage of civilizations.

A broad problem affecting educational foundations is seen in the control of atomic energy. To Compton (11) atomic energy is "just one more step along the path of technological progress" but he states that the society that is adapted for survival in the modern world is one in which an increasing degree of cooperation occurs between diverse groups spread over large areas; that technology requires an ever increasing training and education, as well as a concern that one's activities shall contribute to the welfare of society. Willits (46) pointed out that the main questions with respect to atomic power are those of its impact on war and peace, on power, on politics, and on morals. To implement the concept that atomic energy must be understood and controlled, a bulletin of the University of Illinois (21) brings together basic materials for the orientation of teachers in this area in the form of a resource unit, synthesizing the objectives and experiences basic to understanding atomic energy in an atomic age.

Intercultural relations have been of major concern in establishing foundations. The Ninth Yearbook of the John Dewey Society (27) represented the survival of intergroup tensions, with their accompanying prejudices and hurtful discriminations as a serious threat in our modern world. A series of principles for intercultural education were proposed: that all pupils shall live well together . . . that freedom in a democracy is always limited by the requirement of equal regard for others . . . that pupil groups shall increasingly learn and use the method of conferring . . . that the pupils shall really grow . . . that the pupils shall learn more and more to act on the basis of thinking . . . that each pupil shall build the invariable habit of acting on the best that he has found . . . that each group shall come to know and respect the cultural contributions of other groups . . . that pupils shall understand and appreciate the composite character of the American population . . . that teachers and older pupils shall study the various historic causes and supporting rationalizations of group prejudices, and study the problems of race and the evidence against racism. Brameld (5) studied minority problems in public schools.

He documented the gap between theory and practice, again emphasizing the need for realism in considering foundations. He found that where peoples of various cultures and races freely and genuinely associate, tensions, difficulties, and confusions dissolve. Where such association is not present, prejudice and conflict grow like a disease. Allport (2) found that controlling group prejudice calls for a united attack by every responsible agency and every responsible scientist, moralist, industrialist, educator, housing authority, legislator; by civil service, the cinema, the stage, the radio; by community leaders, psychopathologist, social scientists; and by philanthropic and educational foundations.

The report of the Harvard Committee (22), while purporting to deal primarily with the college level has also important implications for the high school. The report represented the elective system as a divisive force, resulting in compartmentalization of learning and standardization of products. More emphasis on general education at both high school and college levels was suggested as a means of securing unity, and of leading the student to develop desirable traits of mind and behavior.

Caswell and others (9), while finding much that was commendable in American high schools, also found that much needs to be done if the high school is to meet the needs of modern youth. Social goals suggested for secondary education include: developing citizens competent and willing to make every needed sacrifice to make democracy work for all men . . . developing a consuming desire for that kind of public behavior toward other nations which produces peaceful international relationships . . . teaching that we have adequate resources to meet the economic and social needs of all our people and that these resources must be used for this purpose . . . directing the attention of youth to the fact that successful living depends upon adequate personal and public health and upon physical fitness for employment and social and family life . . . showing that America is committed to an economic system of private enterprise and that this system must be healthy, but that government regulation is required to insure its serving the public good . . . pointing out that all men must work to produce for individual and group welfare and that opportunities for work must always be available . . . giving each young person the knowledge he needs to improve his social and economic status to the limit of his capacities.

The social obligation of higher education in America was set forth in the report of the President's Commission on Higher Education (48). General education concerns itself with the fullest possible development of the motives, attitudes, and habits that will enable the student to inform himself and think of himself thruout life. It stresses (a) the importance of being informed, of basic decisions, actions, and opinions on accurate facts; (b) knowledge of where and how to acquire information; and (c) ability to appraise, relate, and integrate facts in order to form valid judgments. General education cannot be achieved by prescribing any single pattern of courses. Altho seeking common goals for all, general education approaches these goals thru different subjectmatter and experience. Such approaches must be as varied as the differences among students.

Continued emphasis on growth and development is shown thru this period in the publication of such books as *Manual of Child Study* (8). Thruout this book it is clear that physical and mental development are interdependent and interrelated, and that maturation is the end of all elaborate processes of change.

Under the direction of Louis Raths (37), workers reported studies in which significant progress had been made by pupils when teachers were led to a deeper understanding of pupil needs and ways of meeting these needs thru teaching operations. Needs identified included belonging, achievement, economic security, freedom from fear, love and affection, freedom from guilt, personal integrity in sharing, understanding, and knowledge.

Young (47) found the use of motion pictures, recordings, and short stories in a program of teacher education for high-school teachers of home economics was successful in developing a sensitivity of teachers to the technics of interpersonal relations, both to those they use and to those that are used on them. She concluded that further improvement in the development and use of such materials would advance the effectiveness of public education. Dirks (15) studying home economics situations, found that comparatively few of the students seemed to have succeeded in establishing friendships and gaining recognition adequate to meet what were termed the basic needs of acceptance and recognition. A few students were consistently accorded a large enough number of rejections to show that definite problems of social and emotional adjustment existed. In view of the large amounts of "unknownness" which many in the group rated, she reported that it was difficult to see how opportunity to establish very satisfying interpersonal relationships could have existed for them within these classrooms.

Fultz (18) reported that a direct attack upon the problem of improving learning thru an in-service teacher-education program which emphasized human relations tended to result in significant increases in social acceptance, reading skills, and intelligence, as measured by psychological tests.

Understanding children is a primary means of approaching the curriculum. Of the many reports dealing with studies made by a local staff, two are cited. A Teacher Education Commission report (35) drew together the experience of many collaborations, but was concerned primarily with the experience and work of one staff. It was found that teachers who understand children think of behavior as caused, accept children emotionally, recognize that each child is unique, know the common developmental tasks which children must meet as well as the scientific forces that regulate human growth, development, motivation, learning and behavior, and use this understanding in making judgments about any particular boy or girl. This study contains many important findings.

A study of the faculty of the Ohio University School Staff (33) resulted in a recording of the characteristics of children at various age levels as a basis for curriculum development and guidance. The general categories used in this study were: Maintaining Personal Health and Promoting a Healthful Living, Achieving and Maintaining a Sense of Security, Developing and Maintaining a Sense of Achievement, and Developing and Maintaining Ever-Widening and Deepening Interests and Appreciations.

Two reports appearing during this period were stimulated by the work of Adelbert Ames, Jr. of the Dartmouth Eye Institute. In a series of demonstrations Ames showed that a perception is only a prognosis and that things around us have no meaning except as we ascribe meaning to them. As a result of these experiments, Kelley (26) concludes that things about us are nothing until we make them something, and then they are what we make them. What we make them can only be determined by what we are and where we have been (our prior experience). Things about us are only clues. Reality, therefore, comes from what we make of these clues, received by our sense organs, *when we act upon them*. External objects lack reality in their own right. They attain importance only when assigned characteristics, distance, and position by an experiencing organism. Cantril (7), in further exploring the concepts proposed by Ames, pointed out that we can only test the reliability of the prognosis a perception gives us by means of some action. Not to act will mean that the perception and the value judgment inherent in it becomes atrophied. This would account, in part, for the ineffectiveness of "abstract" learning, since it does not provide potentialities for purposeful action either for the group or for the individual. The nature of perception can only be understood by tying perception to action, to purpose, and to value-judgment. On the basis of evidence a perception is defined as an implicit awareness of the probable consequences an action might have with respect to carrying out some purpose that may have value. In any perception an enormous number of factors is unconsciously involved, one of the most important of which is the frame of reference from past experience. The perceptions of men that are composed in large part of abstractions are likely to be dangerous since they are divorced from concreteness, and therefore are inadequate guides for purposeful action. Discrimination and real wisdom cannot come from abstractions alone, but only from concrete experience which may be aided by abstraction.

Jersild and associates (24) have presented the principles of child development as applied to the curriculum, drawing upon their own research and the work of others. The point was made that choices must be made as to what children shall learn. These choices at any level should be in keeping with the child's capacities and potentialities. The efficient way to proceed is to relate education to the child's own growth. While educational programs cannot be absolutely geared to child development, educators must be alert for new insights into the resources of child nature and on guard against cultural pressures which are against the best interests of the child.

The place of developmental tasks of adolescence in education was reported by Corey (12) as the required lessons which boys and girls *must* learn to adjust to their culture. For middle-class American young people the more important of these are: coming to terms with their own bodies . . . learning new relationships . . . achieving adult social and economic status . . . and acquiring self-confidence and a system of values. The point was made that developmental tasks should have an important place in determining the direction of curriculum and curriculum change.

Following the research previously reported by Stoddard (41), Schmidt (40) reported a study of 254 Chicago boys and girls between the ages of twelve and fourteen years, all of whom originally had been classified as feeble-minded. The group ranged in IQ's from twenty-seven to sixty-nine, with a mean IQ of fifty-two. Instructional method was characterized by: (a) group planning; (b) group experience; (c) in-school reproduction of situational experiences; and (d) the use of the creative and manipulative arts. A variety of educational materials was used, including field trips, radio broadcasts, films, and stereopticon slides as well as books, magazines, and newspapers. Construction and art materials were used in correlative handwork and in the crafts. Evaluation of progress was made during the three-year experimental period and five years after the pupils had left the center. Twenty-seven percent of the experimental group completed a regular four-year high-school course. Intelligence score changes over the eight-year period ranged from a four-point drop to a seventy-one point gain. Most of the experimental group made satisfactory life adjustments. A control group made little gain in IQ, and life and vocational adjustments were less satisfactory.

Attitudes toward teaching and teachers have an increasingly important place in foundations. Barzun (4) concluded that teaching is not a lost art but the regard for it is a lost tradition. He observes that tomorrow's problem will not be to get teachers even tho, at this moment, that appears to be one of the great needs of the schools. What will be needed, rather, is to recognize the good teachers and not to discourage them before they have an opportunity to establish themselves.

Peterson (34) found that in education the foundation is the teacher, and the best possible curriculum will suffer fatally in the hands of a dull and unimaginative one.

Alberty (1) analyzed the strengths and weaknesses of the subject-centered and the experience-centered curriculums, and resolved the dualism thru an emphasis upon needs as flowing from the interaction of the individual and his environment. When these needs are viewed as a result of the interaction of individual and social forces, a basis is established for the core curriculum.

The staff of the Horace Mann-Lincoln Institute of School Experimentation (42) proposed a theory of curriculum development which utilizes a knowledge of how children grow and mature in American society with its democratic orientation and direction. The major categories selected were: health, intellectual power, responsibility for moral choices, esthetic expression and appreciation, person-to-person relationships, group membership, intergroup relationships, technological resources, and economic-social-political structure and forces. Each of these situations was analyzed on four bases: early childhood, later childhood, youth, and adulthood; and suggestions were made for the operation of the curriculum.

Reporting cooperative approaches to research and study, Mort (30) made a synthesis of basic concepts underlying school administration, many of which are basic to the curriculum. One section was devoted to a description of "best practices," as identified in the studies of the Metropolitan School Study Council. This technic was used in the belief that abstractly stated purposes are often meaningless unless there is some indication of the means by which they are achieved. It was further maintained that most people interpret purposes in terms of the best devices which they know. The study and research program of the Metropolitan School Study Council was therefore directed toward the creation of instruments and the carrying out of research which would develop insight and create desire for better practices.

The question of religious instruction in the schools is in the forefront again. Morrison (29) and Kantonen (25) presented the view of Protestantism which, in general, is that of the separation of State and Church. Rogers (38) proposed that the moral and ethical values of religion are an essential part of training for successful living and they should be part of a liberal education. Thayer (44) found that secularization is consistent with democracy, altho he agreed that there is greater need for ethical, moral, and spiritual training. Fearson (17) outlined the ways in which educational theory in America does not satisfy Catholic ideals—these ideals are documented in the report of the Commission on American Citizenship (10). Moehlman (28) analyzed the shortcomings of the Church, and pointed out that the Christian faith includes only a minority of the people of the world. He saw the emergence of a new synthesis based on the scientific spirit and the democratic faith as essential for worldwide religious cooperation.

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CHAPTER II

Curriculum: Status and Description

HARL R. DOUGLASS, HENRY J. OTTO, and STEPHEN ROMINE

REVIEW of current literature and of responses solicited from teacher-training institutions thruout the United States reveals no great amount of careful, fundamental research on this topic during the past three years. Emphasis here is placed upon studies having research merit. Also included are some books, reports, and studies which, altho not always based on formal research, do indicate principles, activities, and trends which may be useful to persons interested in the general status of the curriculum for the period of 1945 to 1947, inclusive.

This does not suggest that the curriculum is static. Emphasis is placed upon practice. Some reference to theory from time to time is helpful, however, in comparing what was being done with what might have been done. Of primary concern here is the organization and the content of the curriculum as shown by the research of the period covered by this issue of the REVIEW.

I. The Elementary-School Curriculum

Surveys of Status and Trends

Rouse (82, 84, 85) provided a survey of the elementary-school curriculum in Texas which covered: (a) the evolution of the elementary-school curriculum in Texas, (b) the proposed elementary-school curriculum as set forth in the state curriculum revision program of 1934-1938, and (c) the present status of the curriculum in use today in Texas elementary schools. Altho a reorganization and synthesis emphasizing five core areas based on the dominant themes of language, society, security, individual development, and science was set forth in the 1934-1938 program and reemphasized in subsequent bulletins in 1939, 1943, and 1945, the basic pattern which prevailed in 1946 was that of subjects taught in isolation on a daily assignment basis.

Another study by Rouse (83) compared curriculum practices in departmentalized and nondepartmentalized elementary schools. A checklist of 137 items was used in an observation, interview, and questionnaire study. Only fourteen of the ninety-four differences found between the two groups of schools were statistically significant; seven favored each group, but only one of the differences favoring the departmental group was approved by specialists in elementary education, whereas all seven of the differences favoring the nondepartmental group were approved by such specialists.

Otto's (70, 72) comparison of practices in 286 public elementary schools and forty-six campus demonstration schools revealed these two groups of schools to be very similar except that standardized achievement tests and departmentalized teaching were more extensive in the campus schools.

A nationwide survey by Otto (71, 72) included many aspects of the instructional program. Forty-five different subject titles were reported by the 532 schools included in the study. The prevailing pattern of curriculum organization was that of "subjects taught in isolation." The trend toward integration of related subjects was indicated by the fact that only about 50 percent of the schools reported history and geography as separate subjects and nearly one-fourth of the schools reported "social studies." Integration was further evident in a small percentage of schools in which various combinations of reading, spelling, writing, and literature had been made and a still smaller number of schools in which some phases of language arts had been merged with social studies or science. Forty-two different types of co-curriculum activities were reported, only one of which was found in more than 50 percent of the schools, only three in more than 40 percent of the schools, and only six in more than 10 percent of the schools. The prominence attained by health and science was significant. Carter's questionnaire study (18) involving 153 urban and ninety-two rural teachers in Ohio showed that conservation education had gained prominence in teachers' thinking and practice.

In a survey of curriculum improvement since 1925, Rice (77) identified three approaches; namely, (a) those directed toward the creation of courses of study in *subject fields;* (b) those directed toward the development of areas of study and experiences centering around the *major functions of living;* and (c) those directed toward the development of areas of study and experiences arising from the *problems, interests, and concerns of youth.* Concern for curriculum improvement has led to concern for "ways of working" in bringing about curriculum revision which, in turn, has led to greater emphasis upon the major functions of living and the needs of youth. Rice described six significant effects which this trend has had upon the nature of the curriculum.

Since 1942 the Alfred P. Sloan Foundation has been cooperating with selected members of the American Association of Teachers Colleges to implement the training of prospective teachers in applied economics. By 1945 ten teachers colleges were participating in the program (30). Reports of progress and accomplishments of this program are not yet available to any extensive degree.

The old argument about planned and unplanned curriculums appears to be resolving itself into a sensible solution. Articles by Herrick (43) and Hand (38) have done much to clarify the problem. Herrick maintained that every curriculum approach today should consider, at some point, the importance of both children and subjectmatter. Hand insisted that unless the school is to be permitted to function as an irresponsible institution in reference to what is to be learned, it must have a planned curriculum.

Curriculum Content, Procedures, and Appraisal

Children's interests continue to hold a prominent place as a clue to curriculum planning. Heisler (41) found no significant difference between the achievement of comic and noncomic book readers among 600 pupils in Grades I-VIII. Similarly nonsignificant were the few differences found in the personality test scores of these pupils. Baker (7) obtained 9000 questions from 1400 elementary-school children. These questions revealed that children are interested in many topics at the same time and that they may be expected to manifest interest in these topics for several years. A study of children's heroes and ideals by Stoughton and Ray (97) showed that 72 percent of second-grade pupils' interests are associated with the immediate environment and only 25 percent relate to the remote environment. By the sixth grade these percentages have shifted to 42 and 52. Morton's (61) study of children's mathematical interests revealed the grade-by-grade shift of interest in aviation. A very extensive and very useful study of health interests of children in Grades I to XII was made by a staff committee in the Denver Public Schools. (24) Parents, teachers, and pupils were queried about health interests. The results of the study were then organized into a graded schedule for curriculum planning.

Anderson (5) found home-study assignments beneficial to eighth-grade pupils. Krum and Brown (52) called attention to the importance of "the process of change" in curriculum revision and then outlined criteria for evaluating the process. Herrick (42) developed four criteria for appraising procedures used to promote reading development; namely, (a) the criterion of defined goals, (b) the criterion of continuity, (c) the criterion of interrelationship, and (d) the criterion of two-dimensional evaluation. Graham (35) endeavored to find out whether teachers who use democratic methods develop democratic attitudes in their students. She concluded that typical teaching procedures, even tho used by superior teachers, do virtually nothing to develop democratic attitudes, but that there is experimental evidence to show that superior teachers do have a measure of success in establishing democratic attitudes thru the use of democratic methods.

Visual and Auditory Aids

Within the three-year period covered by this report, two professional societies published yearbooks on audio-visual aids; namely, The National Council for the Social Studies (40), and the National Council of Teachers of Mathematics (62).

Large-Scale Curriculum Projects

A definite trend of the times is large-scale curriculum projects sponsored by various types of agencies and carried forward thru the participation of cooperating schools in different parts of the country. Examples of such projects are: the Alfred P. Sloan Foundation study in applied economics which has a "public schools" area (21, 68, 89) and a college area (30); the W. K. Kellogg Foundation project in health education, about which no published reports are as yet available; the Southern States Work Conference (94, 95); the American Council on Education project on intergroup relations; the curriculum program of the National Council of Teachers of English (92) which is designed as a nationwide study and aims to prepare materials in the areas of (a) literature and reading, (b) writing, (c) speech, and (d) listening; two recent yearbooks on the curriculum by the National Society for the Study of Education (63, 64); and the Horace Mann-Lincoln Institute of School Experimentation (57). The latter was organized in 1943 and, as now organized, supports a variety of efforts. Major attention so far has been centered on a series of studies relating to curriculum design. These studies encompass three basic problems: (a) the necessity for a better orientation to the conditions of our technological society (23), (b) the importance of increased recognition of the characteristics of child growth and development (46), and (c) the need for more balance, continuity, and unity in the school program (98). The institute program is seen to have four emphases: (a) the preparation of fundamental analyses basic to curriculum development, (b) field experimentation in associated schools, (c) staff and student research, and (d) publication and dissemination of findings.

II. The Secondary-School Curriculum

Some Factors Influencing the Curriculum

The curriculum is constantly subjected to many influences and controls. A number of these factors were reviewed by Bacon (6) who discussed their action on curriculum planning. Douglass (26) reviewed and summarized official and other agencies which affect the curriculum. Within the field of education, old ideas, new theories, persons, committees, professional organizations, and other separate and concerted efforts wield influence in various ways. One recent study called attention to the importance to curriculum advancement of competent persons in education and placed much responsibility on teacher-training institutions (81).

Outside the school many factors such as legal controls, minority groups, political agencies, business, and other various groups (6) are influential. Douglass (26) classified such agencies as follows: (a) federal authorities and influences, (b) state governmental authorities, (c) local authorities and influences, (d) nongovernmental educational agencies, and (e) pressure groups with special interests. In any complete consideration of the status of the curriculum these influences must be taken into account.

Legal Controls of the Curriculum

The freedom with which curriculum development may proceed varies from state to state, and there is much lack of uniformity. In a study of the legal controls exercised in forty-one states, Jones (48) found that thirty-six state departments of education are authorized or directed by law to develop and prescribe courses of study to be used in junior and senior high schools. In thirty-three states the department of education is authorized or directed by law to prescribe the number of units for graduation from high school. Eleven states authorize uniform purchasing of textbooks, and in three states the constitution authorizes prescription of uniform textbooks. Accrediting agencies exercising some control over the curriculum of the senior high schools are maintained in twenty-nine states.

In nine states local boards of education have full control over courses in the senior high school, while in thirty states local boards exercise control over curriculum offerings subject to approval of the state department of education. Jones concluded that states exercise varying amounts of control either thru direct prescription by law or thru state agencies having legal control. Only a minority of states prescribe specific subjects by law, for example, only nineteen require instruction in health, sixteen have requirements relative to some aspect of the social studies, and twelve with respect to English. In general, powers given to state education departments are exercised sparingly.

Taylor (100) revealed that replies from twenty selected state departments of education indicate that considerable freedom is granted local districts in seventeen states. Massey (59) reported that only three states have specific enabling acts which permit operation of camps by boards of education. She also indicated that twenty states have laws providing for the operation of recreational programs and implied that camps could come under such provisions.

How Many Curriculums?

One extensive study involving 467 secondary schools thruout the United States explored the question of single or multiple curriculums (79). Of 161 schools participating in this particular aspect of the study, 47 percent offered a curriculum of common courses taken by all pupils, plus elective courses. Forty-three percent reported offering several curriculums for pupil choice, within each of which are prescribed courses and electives. The three curriculums most commonly offered were: (a) college preparatory, (b) general, and (c) commercial. However, analysis of graduation requirements within a number of different curriculums reported by the schools suggests that instead of a variety of curriculums there actually tends to be one common program of academic courses, plus some free electives and other prescribed courses in line with the title of the curriculum. In general, the curriculum offerings of smaller high schools, particularly those having an enrolment of less than 200 pupils, were more restricted than in larger schools. Of twenty leaders in the field of secondary education who participated in this phase of the study, eleven favored a curriculum of common courses plus electives, and seven favored several curriculums having prescribed and elective courses.

Common Curriculum Organization

Current educational theory tends to favor more progressive curriculum organization, but practice is limited largely to more traditional types. Alberty (1) stated that the curriculum has not kept pace with the new demands made upon it. However, he also indicated that there is a discernible trend from the subject-centered curriculum rooted in traditional values and subjectmatter to an experience curriculum based upon needs, interests, and abilities of adolescents. Spitznas (96) emphasized the desirability of apprehending the curriculum as a process rather than as a form. Romine reported eight of twenty experts as favoring the experience curriculum and seven as favoring the core curriculum (79). Regarding practice, however, Romine found that 61 percent of the responding schools indicated a curriculum composed of subjectmatter courses, and an additional 19 percent suggested that such courses were correlated in the curriculum. Only 7 percent claimed to have an experience curriculum.

Further evidence of traditional organization was supplied by investigations in Colorado, Iowa, New Jersey, and Wisconsin (65, 90, 10, 37). Taylor (100) found that of twenty states investigated only five recommended a unified curriculum and in two of these it was limited to the seventh and eighth grades. From a study of research on pupil progress, classification, and failure, Leonard (54) concluded that the high school has not yet adapted its curriculum to meet the needs of youth and that success in the secondary school is defined in terms of satisfactory completion of subject units.

There is some other evidence of correlation and combination of two or more subjects previously offered separately (31). Parker (74) reported that analysis of general education programs shows increasing attention to the use of something in addition to subjectmatter as a basis for planning synthesis of courses. Gruhn and Douglass (36), on the basis of extensive questionnaire and checklist surveys, visits to junior high schools, and correspondence with administrators, concluded that there is a trend in the junior high schools toward correlation, fusion, and integration. They also report the degree of current practice with respect to correlation, fusion, integration, large units, and core curriculum organization in the 380 junior high schools.

In 1947 reports from over 400 secondary schools indicated slightly increasing emphasis on correlation of subject courses, fused courses, broad fields, core curriculums and experience curriculums (79). It was also evident that some schools were not greatly concerned with these approaches and that a few others placed less emphasis upon them at that time than in the past.

Curriculum Organization and Educational Objectives

Of 161 secondary schools participating in one study, 40 percent indicated that courses of instruction are organized so as to make some contribution to all ultimate curriculum objectives, with emphasis upon those to which the course is most closely related (79). Thirty-three percent indicated emphasis in organization so as to contribute to those objectives to which the courses were most closely related, with over-all articulation among courses to insure some attention to all objectives. Current theory explored in the same study revealed similar percentages of expert opinion favoring each of these two ideas.

Content of the Curriculum

As used herein the term content includes subjectmatter, activities, and experiences. Several studies indicated a great variety of titles assigned to courses offered in secondary schools. Romine (79) reported unpublished data indicating that courses having 183 different titles were offered in Colorado high schools in 1945-46. Shuey (90) found 217 different subjects in a study of large independent districts in Iowa, and Nonneman (65) found 141 in his study of consolidated school districts in the same state. These findings, together with analysis of courses available in secondary schools over the United States, clearly indicate the growth of the curriculum by addition and its present composition in terms of many courses having a variety of titles.

In one study curriculum experts advocated three important principles for use in the selection of activities and experiences to be included in the curriculum: (a) probable contribution to adult living, (b) suitability for meeting developmental and adjustment needs of youth, and (c) recognition by pupils as of value here and now (79). In an integrative study of literature in the field, Palm (73) concluded that one of the present trends in theory and practice is that of adapting the curriculum to meet youth needs.

Romine (79) found that almost 75 percent of 161 responding schools place primary interest in activities and experiences making a valuable contribution to adult living. Fifteen percent emphasized selection on the basis of meeting youth needs, and a few schools (5 percent) indicated that emphasis was placed upon important aspects of subject fields according to the judgment of the teacher. Increased attention to developmental and adjustment needs of youth was reported by the majority of over 400 secondary schools reporting on trends (79). Increasing emphasis on vocational education, and also on general education, was also reported by many of the schools. Vocational education tends to place emphasis upon general aspects and upon orientation, plus some more specialized courses. Few schools reported adaptation of general courses in English, mathematics, and science to vocational purposes.

The popularity of high-school subjects was investigated by Nonneman (65) and Shuey (90). The former found the ten most popular subjects among Iowa pupils to be Algebra I, English I, General Science, English II, World History, American History, Geometry, Typing I, and American

Literature. Shuey ascertained these to be as follows: English 9, American History, English 10, Algebra, General Science, English 11, Geology, Typing I, and Plane Geometry. Many of these subjects will be recognized as "required" in many high schools. Hence, it may be wondered as to the influence of graduation requirements on the results.

Barton (10) reported that in New Jersey two years of United States History are required by state law and that three years of history and social studies are usually required. He indicated that there is increased emphasis upon Problems of American Democracy and decreased emphasis upon World History. The status of the social studies in Wisconsin high schools is reported by Haas (37).

Graduation Requirements

Such requirements reveal something of the esteem with which various subjects are held. A high percentage of those usually required for high-school graduation are of an academic nature. Model requirements among the schools participating in one study were as follows: English, three units; mathematics, one unit; science, two units; social studies, two units; and health and physical education, one unit (79). An additional unit in each of English, mathematics, and science, and two units of foreign language were commonly required for graduation from college preparatory curriculums. Curriculums of the general type usually had fewer prescribed courses, while college preparatory and specific vocational curriculums had a higher percentage of prescribed requirements (79).

Neglect and Overemphasis

The consultants in Romine's study were asked to rate a number of topics on the degree of neglect or overemphasis which they believed each received in the secondary-school curriculums. Of fifty-two areas or topics rated as to neglect, the ten indicated as receiving least attention were as follows: application of mathematics to daily life; cultivation of scientific thinking; love, sex relationships and courtship; family relationships for boys; the Far East; Russia; labor-management relations; art appreciation; causes of depressions and wars; and creative self-expression in art (79, 80). Other items, indicated as almost as much neglected, include many related to human relationships, world understanding, and other problems of modern living.

Suggested as the ten most overemphasized of twenty-nine areas or topics were the following: athletic teams, war heroes to the neglect of leaders in peace; college preparatory courses in general; abstract mathematical problems lacking application to life; complex fractions; reading of classical literature; highly technical aspects of science; federal aspects of government to the neglect of local and state government; English background of America; and plant and animal classification (79, 80).

Responses from 161 schools did not completely substantiate expert opinion with respect to neglect and overemphasis. However, many of the schools indicated little or no attention to some areas and topics rated as most neglected, and averages of school responses indicated only an intermediate (or slightly greater) amount of attention on most of these areas. Similarly, many schools indicated much or greater attention to topics rated by consultants as overemphasized. Athletic teams, for example, were rated as most overemphasized, and schools gave this item the highest average attention. Study of neglect and overemphasis indicates a need for reevaluation of curriculum content.

General Education

On the basis of responses of twenty leaders in the field of secondary education, Romine (79, 80) concluded that perhaps 60 to 65 percent of the curriculum should be devoted to general education. The data from more than 400 schools indicate a trend toward more attention to general education, altho not quite so pronounced as one toward vocational education (79).

Consumer Education

Briggs (15) surveyed 2915 high schools having a pupil enrolment of 300 or more. Responses were received from 725 of which 26 percent reported offering a separate course on consumer education. Of these, two-thirds of the courses were offered in the eleventh and twelfth grades. Consumer education offered as a part of one or more other courses was indicated by 87 percent of the respondents. The three leading courses making such a contribution were home economics, social studies, and business education. Harap and Mendenhall (39) indicated that during the war many schools formerly offering consumer education as a separate subject had dropped the course, altho nearly all schools offered some wartime consumer education in one form or another. Similar comments were made by Tonne (26).

Examination of syllabi, courses of study, and outlines in 150 school systems supported Briggs' conclusions by revealing that separate courses were largely concentrated in the eleventh and twelfth grades with the majority in the latter year (101). Such courses were reported as usually being elective and one semester in length. However, Turille (101) also reported that a recent survey of 500 schools indicates that two-thirds make no provision for consumer education. Only 12 percent offered separate courses. It appears that more schools claim to teach consumer education in regular courses, but Turille pointed out that "to claim to" and "to do" are not the same. He reported that in a four-state survey (Kansas, Missouri, Nebraska, and Oklahoma) fewer than 3 percent of the schools contacted taught consumer education either as a separate course or thru some form of integration. Turille (102) indicated increasing research in the field and suggested that further experimentation is necessary.

In Romine's study (79) the consultants indicated that much more emphasis was needed on consumer education in the curriculum. Of 161 schools responding, slightly more than one-third reported giving "much" attention to the subject and thirty-two schools reported "little" attention given to this topic. Teaching consumer education thru correlation with other subjects was advocated by Reich (76). Some examples of experimental programs in Florida, Kentucky, and Vermont were reported by Olson and Nutter (69), Seay (88, 89), and Morrill (60).

On the junior high-school level Gruhn and Douglass (36) found that consumer education was most frequently taught in the courses listed below, the percentages indicating junior high schools offering such education in each course:

Courses	*Percent*	*Courses*	*Percent*
Home economics	81	Social studies	34
Mathematics	72	Other courses	10
Commercial	57	Special courses in consumership	4

Aviation Education

Almost 50 percent of secondary-school pupils over the United States have access to aviation instruction. Sixteen states and the District of Columbia have formulated comprehensive high-school aviation programs (28). Sams (87) reported on the growth of aviation education in California and on the topics included in various courses. He also reported on the appropriation made by the state legislature in 1945 to aid aviation education. The California State Department of Education has a proposed course for high schools. A report on programs in fourteen high schools in New York revealed that industrial arts courses include flying model aircraft, ground training and glider construction, maintenance and repair of aircraft, and actual flight training (3). Aviation mathematics, meteorology, radio communication, and the history and social aspects of aviation are taught in related courses.

Safety Education

Widespread concern, at least in theory, for safety education of all types and in a variety of courses was indicated by several studies (2, 9, 11, 13, 56, 58, 75). Woodcock (109) revealed growth in the number of schools offering driver education from eight in 1939 to 350 in 1945. Lindsay (55) pointed out that the number of schools offering driver education in California had grown from a handful to 250, such courses yielding one semester credit or the instruction being integrated in other curriculum offerings. According to Key (50) ten or more states are taking action to accelerate driver education, and Weedon (106, 107, 108) revealed an increase in the number of colleges offering courses in driver education. Some fifty-nine institutions in twenty-two states were reported as making available such courses for credit in 1947. In 1946 Garland (33) reported that more than 300 California high schools taught driver education to more than 20,000 pupils. Anderson (4) indicated that instruction in driving has increased 700 percent during the past decade and that 80 percent of the schools in Wisconsin offer courses in driver education.

Work Experience

The importance and value of work experience was revealed by Jacobson (17). In an extensive study Ivins (45) found that in forty-four states about 1860 work-experience programs were distributed as follows: diversified occupations, 564; cooperative distributive occupations, 545; other cooperative programs, 180; high-school camps, 279; community schools, 291. He reported a growth of about 50 percent in diversified occupations in nine states during the past decade (45). Many state departments of education indicated growing interest in work programs, and the large majority of these departments reported a slight or rapid growth in high-school work experience since the end of the war. A few state departments indicated a decline in the number of such programs.

In one study 55 percent of the consultants favored work experience for all pupils, but of 161 schools reporting only 9 percent made such provision for it in the curriculum (79). Thirty-four percent indicated no conscious concern for work experience, and 44 percent made it available only to those who wanted it and seemed better able to profit from such relatively nonacademic and less formal educative experiences. Of 143 other schools 34 percent reported very little or no attention to work experience (79).

A study of work experience in 136 school systems in thirty-seven states reported on many features of existing programs (104). Of ninety-one communities responding on the extent to which pupils participate, about 66 percent indicated that less than 100 pupils were involved. In almost 50 percent of the communities less than half of the pupils were released from school time for work experience. Brockman (16) reported in detail on existing programs in forty-five secondary schools in twenty-six states, revealing that work experience is being accepted in the curriculum but suggesting that it does not yet enjoy too much respectability.

Mental Hygiene in the Curriculum

There is evidence of a growing tendency to teach mental hygiene in regular courses, such as general education, vocational guidance, orientation, social living, and courses of similar titles. A slight increase in emphasis over the past several years on such courses was evidenced by the annual reports submitted by Colorado high schools. Breinan (14) pointed out ways in which social-studies courses may contribute to mental hygiene, and Smith (93) reported on two basic courses developed in high school for children appearing to have emotional disturbances. One of these included work in English, social studies, and guidance, and interesting progress was reported.

III. Intercultural Education and Education for International Understanding on all Levels

A wealth of literature relating to intercultural education is being developed but little of it can be classified as formal research. The urgent need for better international understanding and better intergroup understanding in our own country was highlighted during World War II and has gained momentum since the close of the war. Interest thus generated led to a variety of activities in schools and with adult groups.

Intergroup understanding and cooperation has assumed a role of considerable importance in social and citizenship education. At the international level it is being spearheaded by the United Nations Educational, Scientific and Cultural Organization (17). In our own country the emphasis is being fostered by various groups which are giving special concern to it. Two departments of the National Education Association, the Department of Elementary School Principals (27) and the National Council for the Social Studies (99), have issued recent yearbooks on the subject. Phi Delta Kappa has created a special committee (44) to give guidance to efforts which seek to construct peace in the minds of men. The American Council on Education, with the aid of funds granted by the National Conference of Christians and Jews, is sponsoring a college (22) and a public-schools study in intergroup relations. Reports of public-school projects, such as *The Story of the Springfield (Massachusetts) Plan* (19) will be appearing in larger numbers in the future.

Responses from state departments of education to a questionnaire sent out by Warren (105) reveal that: (a) state departments may direct the study of intercultural education, (b) state departmental officials believe in the adaptation of present courses, and (c) there is an increasing interest in intercultural education. From a visitation to seven city school systems, Brameld (12) reported that (a) teachers are not trained before service for intercultural education, (b) well-developed plans for citywide programs of intercultural education are lacking, and (c) progress is being made toward improving programs of intercultural education. The United States Office of Education also reported a lack of information on the part of teachers about minority groups and intergroup relationships (103).

On the basis of replies from 123 teachers, Baker (8) reported that those educational institutions located in metropolitan areas have better opportunities for training teachers in service in a realistic way by reason of community resources of minority group life and of speakers. Citron (20), in summarizing 220 articles, reported a wide variety of opinion, materials, and methods for intercultural education. Giles (34) reported the existence of 120 national, thirty-five state or regional, and 175 local organizations at work in the field of intergroup education. Ojemann (67) summarized a series of articles and concluded that superior results follow training young people in the analytic approach, altho they learned much thru analysis of their cultural environment. King (51) analyzed the program of intercultural education in the Cleveland schools. Robson (78) interpreted a program for parent participation in the department of Spanish at the University of Chicago. In an experiment on changing attitudes by means of intercultural education, Russell and Robertson (86) found that more change could be effected at the junior high-school level if parents' attitudes did not interfere. For example, there was a greater change in attitudes toward Negroes than in attitudes toward other groups. Teachers' attitudes were also found to be important.

Johnston (47) reported greatly increased interest in international relations as evidenced by the increasing number of curriculum workshops in this field. Likewise, the literature in the field, as summarized and classified by Dossick (25) is indicative of increased concern. The various approaches to international amity and stability are, however, characterized as being at variance. Jones described some outstanding new college offerings and curriculums. Slonaker (91) reported that the need for a Junior World Conference is growing out of the increasing interest and comprehension of international problems. Joyal (49) found increased emphasis on Latin America, Far East, Russia, global geography, and intercultural relations.

The participation of the Music Educators National Conference in international intercultural relations includes a study of Latin American musicians and their work, the exchange of teachers, the encouragement of Latin American music education (53). Oakes (66) pointed out ways in which science instruction may constitute a superior and effective approach and contributes to international understanding. He listed important organizations at work in this field.

IV. Appraisal of the Research Reviewed

During the war years curriculum research necessarily suffered curtailment. The end of the war brought a revival of interest and activities in curriculum revision, but the teacher shortage has undoubtedly checked some of this work. Most of the projects which have gotten under way since the close of the war have not yet progressed far enough to produce published reports. For these reasons the quantity of careful, fundamental research available for this review was somewhat limited.

Of the research reviewed, many studies were based upon the questionnaire or checklist technic; thus the results are subject to the limitations customarily associated with this type of study. In some cases two or more studies investigated the same areas, items, or problems. Definitions were not always in agreement; thus caution should be exercised in making comparisons between results obtained in such studies.

In general it appears that curriculum practice has not kept pace with theory, altho some progress has been made. Increasing attention in the curriculum to activities and problems of modern living is evident, but these usually are dealt with within a curriculum more typically conservative than progressive in organization.

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CHAPTER III

Methods and Materials for Childhood Education (thru Grade VI)

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THIS chapter summarizes studies that were published during the calendar years 1945, 1946, and 1947, and that were concerned with methods of teaching and teaching materials for preschool, kindergarten, and elementary grades I thru VI. For a treatment of the three-year period immediately preceding 1945 the reader is referred to the June 1945 issue of the REVIEW. The areas treated in the present chapter were dealt with in that issue under the chapter headings *Methods of Teaching* and *Auditory and Visual Education*.

The body of general literature on methods of teaching available for the three years under consideration was substantial and, as noted in the June 1945 report, this literature showed a tendency to cite the findings of research and the summaries of investigations. Altho this three-year period covered the end of World War II, there seems to have been a decrease in the quantity of materials discussing the implications of the armed services educational program. The special commission of the American Council on Education (32) published its report on this topic in 1947. There may have been a tendency to await and accept this statement as definitive.

Some general research dealing with grouping, departmentalization, and "progressive education" appears. There was also research dealing with specific technics and materials. It is significant, however, to note the increased emphasis on such topics as the democratic method, group dynamics, and mental hygiene in the classroom.

Together with these emphases on child development and group relationships there have been in a few general publications attempts to unify and synthesize the curriculum experiences provided for boys and girls. Examples of such attempts can be seen in the published volumes resulting from the research program of the Horace Mann-Lincoln Institute of School Experimentation (43, 85). Mursell (61) has devised a series of six psychological principles of teaching. Huggett and Millard (41) dealt with the psychological foundation of instruction and practice, and treated, in separate chapters, the major curriculum areas.

Preschool and Kindergarten

Early childhood education again received generous treatment in the literature and was the subject of a yearbook of the National Society for the Study of Education (66). In this volume Anderson treated the theory of childhood education, and Updegraff and others summarized the research on the curriculum in that area. The Educational Policies Commission (63) reported that "research and our experience attest the value of nursery school and the kindergarten and of correlative programs in parent education." Heltibridle (37) traced the historical development of the kindergarten program during its period of transition from one characterized by a formal program to that with which we are familiar today. Redfield (71) investigated the importance of home influences on the preschool child. Herr (38) concluded that pre-first-grade training is an important factor in success in learning to read among Spanish-American children. She believed that her data justify the presentation of a pre-first-grade reading readiness program to children below the normal age of school entrance. Allen (2) found that beginning first-grade children need a period of orientation that provides for the child self-chosen activities and a socialized environment. She did not, however, draw any inference for the kindergarten program from her study. Andrus (5) described the physical, social, and other needs of preschool children and described the daily activities of children participating in a nursery-school program.

The Background of Method

The conflict between "progressive" and "traditional" practices has not yet been resolved. Buswell (20) analyzed four problems of method underlying newer instructional procedures. He took the position that learning needs to be organized and related, sequential, and associated with the time factor. He showed the need of scientific inquiry. Weber (91) in a reply to critics of "progressive" methods listed nine points on which the psychologists of the leading schools agree. He cited research findings to indicate that the net result of the practices evolving from the "progressive" point of view is good.

Hildreth (40) made a critical appraisal of the policy of continuous promotion. She stated that in recent years the newer emphasis on the child as the center of the educational process and fuller appreciation of the disastrous consequences of failure from a mental hygiene standpoint resulted in an increase in promotion rates. Yet if children lacking the prerequisites are required to meet inflexible achievement standards, failure results and promotion signifies progress in name only. Hildreth listed as implications of her appraisal the need for (a) individualized teaching of basic skills, (b) wider range of materials, (c) grouping of children within the grade, (d) a functional school library, (e) a variety of reading materials, (f) nontraditional instructional materials, (g) an understanding of pupils, (h) small classes, (i) grouping for special purposes, and (j) avoidance of a narrow remedial drill type of teaching. She concluded that promoting children continuously should not set up insuperable obstacles to teaching; on the contrary it could become the stimulus for rethinking education in terms of the individual pupil.

In an attempt to discover the effect of departmentalized teaching Rouse (74) studied the fourth and fifth grades of two groups of schools, twenty with departmental and twenty with nondepartmental organization. By observation, interview, and questionnaire she found only fourteen statistically significant differences. These two groups of schools were reported as being not so different in actual practice as the theories underlying the various types of organization seem to indicate. The two groups were practically equal in the scope of their curriculum but the nondepartmental groups were more in accord with presentday theories of education. The available research on departmentalization was summarized by Seegers (78). He listed thirteen references on the topic and pointed out the limitations of educational procedures in schools in which there is departmentalization. He stressed the effectiveness of integrated teaching. He decided that departmental teaching lends itself to efficient teaching of isolated skills and that it may be superior to fragmentary, unimaginative teaching by a single teacher. He concluded that departmentalization is not a particularly good plan of organization for teaching.

The controversy between the planned and the unplanned curriculum still continued. Herrick (39) concluded that there was no such thing as an unplanned curriculum. He stressed the importance of teacher-pupil planning and outlined the basic concepts of the experience curriculum. Curriculum planning is an essential part of the learning process itself. The 1945 yearbook of the Department of Supervision and Curriculum Development (26) stressed the need for the democratic type of planning in the classroom. Examples of good practice were given.

From a study of practices found in better schools Mort (58) developed four over-all pertinent characteristics related to instruction, curriculum, and teacher personnel. Wingo (93) pointed out that to an increasing degree much of the work of the elementary school is being carried on by a type of classroom organization variously called "unit of work," "project," "activity," "center of interest," or some other name. He indicated the danger inherent in the "unit of work" of substituting an equally undesirable, but new, atomism for the old. He listed five criteria for the development of units.

Children's Interests

During the period covered by this issue, Emily V. Baker (12) reported her research on children's questions. She collected 9280 questions from 1402 children in Grades III to VI in laboratory and public schools. She found that girls tend to ask more questions than boys, that subjectmatter interests are in varying degrees common to both girls and boys, and common to all grades from three to six, that many interests run concurrently, that interest in a given area may be expected to continue for several years, and that children are interested in the origins and causes of natural and social phenomena. Children want help in interpreting the facts and situations they observe and they want help in understanding the school situation. Stewart (82) found that children prefer assignments that involve the use of multiple textbooks, group practice, and self-direction in finding materials in books. She studied the direct opinions of 546 children in Grades IV, V, and VI as revealed on questionnaires. She recommended that teachers plan assignments that utilize the above mentioned technics.

Lindsey (49) studied children's records of their use of time in school as a means of evaluating the programs of the elementary school. She directed the children of ten classrooms in five elementary schools in the keeping of records of how they actually used their time. She concluded that the technic is a helpful one and recommended that teachers use it, even with one child at a time. Lindsey also discovered that time is needed in the school day for teachers to plan with and for children. Tschechtelin (88) experimented with self-appraisal of children in fourteen schools of Indiana.

Sherer (79) screened a list of 3665 questions on all phases of aviation asked by 1150 children in kindergarten, Grades I, II, and III in order to find out what primary-grade children want to know about the quantitative aspects of aviation when they are free to ask whatever they please. He also studied (a) questions about aviation asked by children during school activities while studying aviation and (b) narrative accounts of children's questions, comments, and activities during extensive classroom studies of aviation. Drill (27) in an effort to get at the science interests of children studied 47,330 reports of free discussion periods of children from thirty-eight communities in New York State and critically analyzed 19,211 which pertained to "topics which are or might be included in an elementary science program." She found that an average of 41 percent of all the content for all the grades included an interest in science and that boys were more likely to mention science topics than girls. Children were found to be more interested in individual plans, animals, machines, or units of the physical environment than they were in societies or organisms in relation to their environment or in the stars, moon, sun, and planets. Children were more interested in compounds and mixtures than they were in elements; and children showed some evidence of having been indoctrinated with superstitions, particularly concerning the moon and stars and animals.

Readiness

Readiness as it pertains to the development of children had some further attention in the fields of reading and mathematics. Moser (59) conducted one such investigation on the second-grade level in an attempt to re-evaluate the relative contributions of maturation and environment. He chose prealgorismic growth of the fractional concept when instruction emphasized meaning and the structure of the number system. He concluded that (a) at the present time teachers do not know what to do about readiness; (b) a functional approach to the problem of readiness is indicated; (c) the teacher should provide a highly simplified version of the basic features of the environment to which the individual must eventually adjust; (d) there is experimental justification for presymbolic activities and they, together with manipulative activities, are attractive to children from seven to ten; (e) there is a need for a reconsideration of the grade placement program of the Committee of Seven; (f) simultaneous instruction with halves and fourths tends to promote transfer of training.

In the field of art education, Landis (48) developed a theory of "meaningful method" as opposed to a "directing" or "free-expression" or an "eclectic" method. In Landis' "meaningful" method an attempt is made to develop in the child a self-control instead of control from without. Thus, for Landis, art becomes a unifying process, an objectification process, a communication process, and a pervasive element in the life of the individual. O'Donnell (67), drawing upon both *a priori* and experimental sources covering a period of twenty-five years, presented an attempt to establish the thesis that the creative dance is an essential educational feature of a democratic society. She presented materials and methods by which all primary-grade teachers may raise "the quality and frequency of instruction in creative dance." Lists of dramatic and imitative activities were included in the study. Only those selected by children and observed as being satisfying to children were included. Bibliographies of music for the dance and for dance accompaniment, including records, were also given and were so keyed that teachers would readily select music related to or suitable for typical movements, designs, and compositions. The further use of informal dramatic activities in the intermediate grades was recommended by Merker (53).

The use of pictures, dramatizations, pantomimes, constructive activities, excursions, and free reading are recommended by Sister Mary Carmelita Kus (46) for use in vocabulary development in an activity program.

Pupil Activities

Jensen (42) surveyed available literature and analyzed the data from questionnaires returned by seventy elementary-school principals in Los Angeles in an effort to ascertain the status and probable value of activities supplemental to the curriculum. She found that training in thrift was the most frequent activity and student councils the least frequent. Music activities were rated by the principals as being of greatest value to children. No activities at all were offered in Grades I, II, and III in schools with enrolments of 100-299 or 1100-1399 (the smallest and largest studied). All schools reported activities for Grades IV, V, VI. Fewer activities were found in the largest schools and the greatest number of activities were reported by schools with enrolments of 500-699. In Grades IV, V, and VI safety patrols were the most frequent pupil activity. Assemblies ranked second. In the lower grades, only the assembly appeared with enough frequency to compare with the activities in the upper grades.

In a study by Otto (70) the largest variety of pupil activities engaged in within the classroom was found in medium-sized schools. Otto also found that the use of the lunch program as a laboratory related to health instruction is gaining acceptance and that community projects are being used in a large number of schools. Otto stated that these projects reveal an encouraging trend even tho a majority of those most frequently reported were those of lesser educational value.

Personal Development and Group Membership

Both the general literature and research during the three-year period covered by this issue indicate that important implications for teaching methods are coming out of the field of mental hygiene. Frank (31) stated that mental hygiene is not confined to the field of psychiatry but has a place in the classroom. He contrasted the older type of classroom with more recent programs and practices wherein teachers encourage socializing, wherein playing may contribute to learning, and wherein group activities are emphasized. The December 1946 issue of the REVIEW (84) devoted a brief section to mental health in the elementary-school classroom. Snyder (81) summarized the experimental and survey studies dealing with the mental hygiene of school children that had appeared in the literature since 1936. Brewington (17) outlined a mental hygiene program for elementary schools. Waller (90), as a result of a survey of five elementary schools of Washington, D. C., recommended that (a) teachers make a study of mental hygiene and modern guidance technics, (b) schools keep more complete and permanent cumulative record files, and (c) teachers become more familiar with tests of personality. Hartsig (36) found, from a study of the guidance services in 208 elementary schools that (a) there appears to be a need for improvement in utilizing recorded data, (b) most of the schools reporting indicated that teachers need help in observing children and in interpreting their observations, and (c) more effective ways of interpreting the educational program to parents in groups and thru individual conferences seem to be needed. The Commission on Teacher Education (3) published the results of a cooperative, three-year project which presented technics for study of child development at the various grade levels.

Selected research dealing with a variety of problems related to grouping of children was reported by Smith and Dolio (80). They stated that the basis for grouping should involve more than the IQ or achievement. Grouping has come to have as its objective the placement of each individual within a group in which he will work better, where he will have status and a sense of belonging, where his mental health will be safeguarded and improved. Some of the main points from the selected research are given in a running account.

The National Council for the Social Studies (62) reported current practices and trends in social education for young children. Chapter III, as well as others, gave the findings of research. Thruout the publication the emphasis was placed upon the problems of children in groups. The American Council on Education (4) thru its project of Intergroup Education in Cooperating Schools issued a mimeographed sociometric work guide. Olson (69) reported how a sociometric study and an analysis of the situational factors in the social structure were made of a third grade. He listed the treatment recommended for the group and described what one teacher did. He made a follow-up study after a period of six months. Little improvement in social relationships was found. The children were then regrouped; and more improvement in social relations resulted. Olson recommended that numerous experiments in grouping using sociometric and other appraisals be made. The reader is referred to a compilation by Bronfenbrenner (18) of a series of articles from the journal, *Sociometry*. The sociogram and preference questionnaire were used by Flotow (30) in studying social relationships of school children. A sociometric test was given to 135 children in Grades IV to VIII. Each child was to name the three children with whom he preferred to play, work, and sit. The score given to each child was the number of choices he received from others. The scores ranged from 0-28. Most children received fewer than ten. Six percent received three or less, and 12 percent scored fifteen or more. The test results were plotted in a sociogram. Flotow concluded that the sociometric test can be used to give the teacher a clearer view of the entire problem of social relationships within the classroom and that it would point up for the teacher the direct relationship between everyday teaching problems and the social adjustments of children. A study of sociometric patterns in the elementary school was also made by Bedoian (13). Harris (35) made a study of some socially unadjusted children in the elementary grades. Morrison (56) used sociometric tests to discover that children tend to choose friends who resemble themselves as to chronological age.

The available research concerning the social and personal integration of nine-, ten-, and eleven-year-old children was brought together by Blair (15). He suggested principles of guidance based upon the distinctive aspects of development during these years and indicated problems requiring further study. This is an important and significant summary.

In Tschechtelin's study (88) 1542 elementary children in 140 classes in fourteen schools rated themselves and one another. Tschechtelin also obtained ratings of the children from 485 teachers, getting a total of 409,536 ratings. It was found that boys seem to underrate themselves but rate themselves increasingly higher thruout the grades. Individual girls in all grades rated themselves higher than they were rated by the boys in their classes, higher than by the girls in their classes and higher than by teachers. Questions were raised by Tschechtelin as to whether boys become more secure, or more defensive and compensatory as they progress thru the grades. Questions were raised as to whether girls are better adjusted than boys or only think themselves better, or are overcompensating. Haggard (34) in an attempt to indicate some basic relations between learning and adaptive behavior in general, appraised certain facts and theories of learning. He took the position that learning involves the modification of the individual's "drive states" or motivational pattern and not his response patterns *per se*. He concluded that the learning of desirable response patterns will follow when desirable motivational patterns are learned. Arisman (7) from a survey and analysis of the literature found that there is abundant evidence of the need for concern about the high incidence of emotional problems and that it is essential that the schools recognize and develop more adequate curriculums which will meet the desires, tensions, drives, and interests of children. He described the motives for classroom behavior in terms of the relationship between the child and his work, the child and his teacher, the child and other children and the group, and the relationship between external forces and the classroom behavior.

A method for evaluating the growth in attitudes of elementary children was studied by Erro (29). An evaluation device, based upon 500 classroom observations, was constructed thru the cooperative effort of teachers. These observations were generalized and, after each generalization, were listed examples of behavior characteristic of the specific aspect that could be expected on each level: primary, intermediate, and upper elementary. Erro recommended that evaluation technics should be constructed by those who are to use them. Brueckner (19) discussed the findings of a study of attitudes on war-related issues of children in Grades IV to XII. Since the extent of agreements and disagreements by pupils on the forty issues was found to differ little from grade to grade, he raised such questions as: Are there factors outside school that contribute more than instruction to the development of attitudes? Do children's attitudes reflect those of parents? To what extent do radio, movie, reading matter that is accessible, and other factors determine attitudes? Robertson (73) concluded that the school must work closely with parents and other adults who are influential in shaping behavior.

In a general treatise on democratic education Schneideman (77) described in detail the procedures she used in instruction to democratize the work in her classroom. Stone (83) from a study of pupil learning activities concluded that experience involved in conducting meetings and understanding the principles of democracy should play a prominent part in programs of democratic citizenship education. He found thirty activities which he classified as "minimum essentials." The activity rated lowest in effectiveness by teachers and leaders was to "determine and enforce penalties for violations of group regulations." Sanford (76) in considering the differential effect of dominance and autocracy on child development reasoned that authority should be of such a kind and degree that the child can accept it and make it his own. As the child's authorities become more and more internalized, external pressures are gradually relaxed. Adams (1) also studied the behavior of children in democratic and autocratic social climates. He found that it is possible to establish autocratic and democratic social climates in the classroom when the teachers know the characteristics of these two social climates. The behavior of those operating in the democratic climates was found superior in six points. The behavior of those operating in the autocratic climates was found superior in two points.

The Department of Elementary School Principals (65) issued a yearbook that contains descriptive material about methods of intercultural education used in elementary schools. Murphy (60) studied the contribution of the elementary school to American intergroup education. She found that no state has a well-financed, organized program in intergroup education and that present intergroup programs are not adequate to the great need that exists.

Studies were made of ways and means of getting a closer relationship between the school and the home and community. The Twenty-fourth Yearbook of the Department of Elementary School Principals (64) reported many illustrations of ways to bring this about. Conner (22) studied the effect of parent-teacher cooperation in the study and planning of educational activities upon the progress of pupils in school. In three elementary schools the parents of fourth-, fifth-, and sixth-grade pupils were invited to participate in two-hour weekly conferences with teachers and children, in observation of pupils in action, and in discussion of teachers' plans and of problems of parents. Control schools were set up. The matched-pair technic was used. The experimental groups made significant academic gains. Pupils improved in their personal-social status. Provisions in the home for educative experiences increased. Experimental classrooms were, at the close of the experiment, rated superior to the controls in quality of educative environment and in quality of pupil participation. D'Evelyn (24) made some practical suggestions for individual parent-teacher conferences. Coulter (23) analyzed the parent-teacher conferences held in one school system for one semester. Coulter recommended that teachers should be chosen who are willing to spend time on parent-teacher conferences, who have a knowledge of child development, and who can effectively deal with people; and public schools should set up in-service education programs in the technics of interviewing.

Teaching Materials: Audio-Visual, Library, and Others

Caswell (21) described four types of aids to instruction that reflect the scientific movement in education: (a) research bureaus, (b) provision of written and construction materials, (c) audio-visual aids, and (d) standardized tests.

The bulk of the research on teaching materials that appeared in the three-year period under consideration dealt with reading materials. Altho this chapter is not concerned with research limited to a specific subject field, a few such studies that have general significance are reviewed here. Edgerton (28) studied three widely used children's encyclopedias to determine just how difficult they were to read. He recommended that a greater amount of vocabulary control and a higher percentage of common and already familiar words be used. He found that pictures are valuable aids to comprehension and that there should be more use made of action-type picture panels and pictographic maps and charts. Rinsland (72) studied over 200,000 papers containing the writings of children thruout the United States and determined the frequency of the words used therein. The papers were from the first eight grades. They included such types as personal letters, expositions, original stories, poems, examination papers, conversation reports, projects, and others. Children use a surprisingly large number of different words on each grade level. The list as compiled contains the 14,571 words occurring three or more times in any one grade. Both the raw frequency with which the word occurs in each grade and the total frequency for all grades are given and a symbol is used to indicate the frequency group into which the word falls.

Rue (75) issued in 1946 the first supplement to her subject index to books for primary grades which was last revised and published in 1943. This 1946 supplement indexed, under subject headings, more than 225 titles published during 1942-1946. Levels of difficulty and usability for children and teachers are indicated. Morse (57) presented an annotated list of selected books for children classified according to age levels. In 1946, the Association for Childhood Education published a list of children's books costing fifty cents or less (9); its 1948 list of approved books for young children includes those costing seventy-five cents or less (10). The Association (8) also revised its bibliography of books for young children. This list contained annotations and suggested age-level interests. Trager (87) issued a list of intercultural books for children edited from twenty-two bibliographies. Twelve criteria were set up for making the selection. Betzner (14) listed the recordings of children's literature available thru the American Library Association and other sources. She pointed out that the school, together with radio, film, phonograph records, television, "comics," and the theater provide media for presenting literature to children.

The vocabulary of selected preprimers was analyzed by Johnson (44). Certain aspects of second-grade readers were studied by Grady (33). A study of foreign nationalities in selected third-grade readers was made by Womack (95). Lucas (52) analyzed the fable, fairy and folk tale, mythical, and legendary content of selected third-grade readers. Louis (51) made a similar study of selected sixth-grade readers. Dalton (25) analyzed the rural life treatment given in 210 books in forty reading series. His study centered around the treatment of rural problems, rural topics, and literary stories about rural life. He found that rural life in all its aspects is not adequately treated. Bond (16) surveyed the literature relating to supplementary reading material for third- and fourth-grade science. Whitney (92) studied artists and their works used in the intermediate grades.

An analysis of sources of materials for education for world citizenship was made by Townsend (86). The place of the American folk ballad in children's song literature was investigated by Sister Mary Bernard Kannapel (45). She traced the history of the ballad, its educational significance, the place of the ballad in the school program and listed criteria for the selection of folk songs. She recommended the inclusion of more American folk music in the curriculum. Lammers (47) selected stories from American Indian folklore suitable for use with elementary-school children. She outlined the history of the folk tale and the importance of its use in units of work. Olson and Fletcher (68) reported on the Sloan Foundation Experiment.

Recent experimental investigations and research studies reported in the field of educational motion pictures were brought together by Long (50). He included investigations dealing with (a) the use of and effectiveness of educational films in teaching special subjects, (b) their effectiveness at various grade levels, (c) their use in developing attitudes and understandings, (d) standards of evaluation of educational films, (e) the comparative effectiveness of different methods in their use, (f) the grade, range, and economy of time of educational films, and (g) historical and documentary investigations with educational films. Anglin (6) developed a guide for the use of films in the teaching of science in the intermediate grades. The Association for Childhood Education (11) devoted its first 1947 service bulletin to the use of audio-visual aids with children. The United States Office of Education jointly with the Radio Manufacturers Association (89) issued a set of basic standards for the selection and utilization of school sound systems.

The implications of the Armed Services Educational Programs that seem to pertain to instruction in the elementary school are chiefly those concerning the teaching of reading and the use of audio-visual aids. As a result of a survey of all the major studies of training-aids conducted by the armed forces, Miles and Spain (54) listed eleven implications for civilian education.

Millard (55) also made a study of the development and use of audio-visual aids in the training program of the United States Armed Forces. Witty (94) concluded that the Armed Forces Educational Program was characterized by: (a) definite objectives, (b) careful study and proper classification, (c) use of functional materials, (d) small-sized classes, (e) wide application of carefully developed visual aids, (f) hygienic conditions insuring a sense of security, comfort, and general well-being, and (g) thoroly trained and enthusiastic instructors.

Summary

It is difficult to integrate the findings of research on teaching methods and materials. Much of the research was diverse and scattered. However, certain features do stand out. The implications for teaching inherent in continuous promotion seem not to be fully realized by administrators and teachers. The issue of departmental *versus* nondepartmental teaching has not yet been completely settled altho evidence on the elementary level is piling up in favor of the nondepartmental type or a modification thereof. Much attention was given to learning activities: creative, cocurriculum, and child-chosen. Children's interests were studied both as a means of curriculum planning and as a basis for insights into child behavior. Much concern was shown for the improvement of mental hygiene in the classroom. The personality adjustment of children held a prominent place in the research. The investigation of group dynamics is increasing. Correspondingly, sociometric technics seem to have been more frequently used by teachers who were becoming aware of the social relationships in their classrooms. The social climates of democracy and of autocracy in the classroom were further explored and attention was given to the development of attitudes by children. School-home and school-community relationships were studied and the importance of teacher-parent cooperation was indicated. Audio-visual and library materials were prepared and appraised as were other materials used by teachers in developing units of work.

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CHAPTER IV

Curriculum: Methods and Materials (above Grade VI)

FREDERICK H. BAIR and WILLIAM E. YOUNG

This chapter summarizes the research reports and discussions based on research findings dealing with curriculum methods and materials in the secondary school and college during the calendar years 1945, 1946, and 1947. Perhaps the most significant research in this area during the three-year period was reported by the American Council on Education thru its Commission on Implications of Armed Services Programs (10, 13, 21, 32, 36). Much attention was given also to methods and materials in general education, intercultural education, international education, and work experience. Moreover, there was considerable emphasis on the use of various auditory and visual aids. While probably not more than a score of scientific investigations on methods were published, other works such as the Report of the Harvard Committee (24) and bulletins of national associations increased the number of studies that merit careful consideration here.

The Background of Method

Symposiums on the curriculum were furnished by the Eighth Yearbook of the John Dewey Society, edited by Caswell (9) and a volume edited by Douglass (15). Studebaker (48) outlined the probable course of development in secondary education as based on an examination of present trends.

Annotated bibliographies on the research as well as the general literature on the curriculum were presented regularly in the *School Review;* for example, see the January 1947 issue (27). Drag (16) studied curriculum laboratories in the United States, indicated their present distribution, and suggested technics of organization, development, and operation of curriculum laboratories.

Certain inadequacies in curriculum research were set forth by Mackenzie (30). Two characteristics were pointed out: (a) secondary curriculum studies have been undertaken without relating them to a well-reasoned theory as to the nature of the curriculum; and (b) research has often failed to attend to "the total constellation of factors operating" in any situation. He concluded that "the curriculum has not been studied in the total school and community context." It was partly so studied by Albrecht (2) who investigated the results of the first five years of the Texas inquiry into secondary education. Her survey included thirteen topics such as mental hygiene, curriculum readjustments, and improved methods.

Armed Services Training Programs and Audio-visual Aids

What can the schools and colleges learn from methods of education used by the armed forces? Chambers (10) reviewed some twenty studies and summarized the contributions as follows: (a) effective procedures of classifying and grouping personnel pointing to possibilities of improving aptitude testing, guidance, and student aid; (b) clear and purposeful objectives; (c) authentic, up-to-date, and functional methods and materials; (d) a practical curriculum of immediate value; (e) motivated instruction; (f) an integrated curriculum in effective series; (f) the production, distribution, and use of visual and aural aids on an extensive scale.

Goodman (21) asserted that the significant characteristic of armed services training was change. Specific need was the sole criterion for the inclusion of courses or content. Realistic training required adequate facilities and aids. Davis (13) reported in some detail concerning selection and classification procedures in the armed services training program, and Witty (52) described the teaching of the three R's.

Foreign language teaching (32) came in for intensive study, leading to caution against forcing too far analogies between wartime conditions and the ordinary conditions of language learning in the peace-time secondary school and college. Of especial interest here is the emphasis on area studies, and the technics found effective. Agard and others (1) made recommendations for the improvement of foreign-language instruction in both high school and college founded on the report of the Commission on Trends in Education of the Modern Language Association of America.

According to Spaulding and Marvin (47) the construction of textbooks could be improved if publishers would make use of the experiences of the armed forces. The Armed Forces Institute attempted to build self-teaching texts so that learners of varying degrees of intelligence would be able to follow every word, line, paragraph, and illustration, with no outside interpretation or supplementation. One of the important contributions of the military educators was the effective use of multisensory, and particularly of visual materials. Hoban (26) and Miles and Spain (36) concluded that visual and auditory aids were essential to the achievement of the goals of civilian education. From the vantage point of over a quarter of a century of observation, Freeman (19) reviewed the serious obstacles to effective use of audio-visual materials.

In an investigation of the use of motion pictures and film-strips in the schools of the Southern Association of Colleges and Secondary Schools McCallum (33) found that they were used in more than 46 percent of the schools and in all subjects. Certain basic instructional practices were recommended: (a) motion pictures and film-strips should be used as a part of the regular class work; (b) the information should contribute directly to the unit of work; (c) the material should be adapted to the interests and capacities of the group; (d) the general topic should be discussed prior to the film showing; (e) not more than two films, and these related, should be shown during one period. Six over-all recommendations were made as a result of the study. One of these was to the effect that the complete development of audio-visual programs in all schools depends upon organized preservice and inservice education, which will prepare teachers and administrators in the proper usage of films. Ettinger (17) evaluated the available visual aids in business education and investigated the extent of their use in New York City. A large number of useful aids were found to be available but used to an extremely limited degree. The status of audio-visual education in city school systems was summarized in a *Research Bulletin* of the National Education Association (40) in 1946.

Radio was discussed in detail by Levenson (29) who traced the growth, use, and possibilities of radio in schools. The evaluation of a project of school broadcasts was carried out by Woelfel and Tyler (53).

Special Postwar Problems

Hess (25) summarized the minimum requirements for a high-school diploma in all states, the District of Columbia, and Alaska. He gave information about the use of the Tests of General Educational Development of the United States Armed Forces Institute in the granting of equivalent certificates. Allen (3) analyzed the problems of high schools in meeting the specific needs of veterans. Comprehensive studies of curriculum adjustments in secondary education necessitated by the impact of the war and social change were presented in bulletins of the National Association of Secondary-School Principals (38, 39).

There is little evidence that atomic energy developments have, as yet, had much direct influence on the curriculum. A comprehensive study unit on the atomic age, edited by Hand (22), was published as a University of Illinois research bulletin in 1946. An opinion poll of school administrators on what emphases concerning the atomic age are desirable in the high school was reported (37). It is doubtful if the true concern of the schools with this problem was adequately reflected by the amount of published research during this period. There were, of course, a great many general discussions of the atomic problem in the literature.

General Education: the Core Curriculum

The Report of the Harvard Committee (24) has been chiefly studied and criticized for its proposals for a general education in school and college to serve as a unifying and liberating force based on a common knowledge, familiarity, and feeling. The Report placed first the improvement of teaching. Flexibility in the choice and conduct of courses was supported. Evidence was cited of the success of the tutorial system with gifted college students, altho its success has not extended to the teaching of "most of the physical sciences." The present textbook was adjudged inadequate—particularly so for the teaching of adults who want insight rather than information. A need for "radical research into the principles of comprehension" was indicated. Evidence was cited to show that sound-motion pictures can increase greatly both clarity and interest of presentation. McConnell (34) interpreted the experience of the University of Minnesota as indicating that students profited more from a combination of group instruc-

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CHAPTER V

Curriculum: Change and Improvement

GORDON N. MACKENZIE and MARCELLA R. LAWLER*

CURRENT literature on the curriculum includes numerous general or specific recommendations for change. There is, also, renewed attention to the methods by which change can be brought about. Whereas earlier attention to methods for change tended to center on steps in the revision of courses of study or sequential stages in the organization of curriculum improvement programs, more recent efforts have focused on defining the process of change and exploring or studying some aspect of it. Curriculum change is now viewed as a much more complex problem than the predominant curriculum literature of the 1920's or 1930's made it appear to be.

Curriculum discussions often reveal dissatisfaction with results of earlier efforts at change and indicate the urgency for making changes speedily. Criticism is frequently made that altho philosophy has been changed and new objectives have been enumerated, and even a course of study developed, classroom practices have been modified but little. The apparent growth of general social lag and maladjustment has stimulated many to seek ways of speeding curriculum improvement. Some have viewed existing curriculums as indications of social lag and unbalance. For example, the absence of relationships between the learning experiences in many schools and the problems of presentday living is viewed by some as indicating a needed change in the curriculum. Possibly the basic principles governing change of the curriculum are the same as those controlling change in other areas of life.

However, while curriculum change may be just one aspect of the total problem of social change, there are other far-reaching implications of the idea of curriculum change. The curriculum, depending on its nature, may be an important means for bringing about wider social change. It may even be viewed as a possible means for retarding change, for maintaining the status quo, for facilitating adjustment to new conditions or for leading in the definition of new goals and developing the means for their attainment. The interaction of the school curriculum and social change is something which should be understood more clearly by educators.

Altho the research bearing upon principles underlying the process of curriculum change is still limited in extent, the character of recent attention given to the problem, the importance of the problem, and the promising character of some of the studies under way, suggest that review and analysis at this time may help to clarify this dynamic aspect of the curriculum field.

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The Meaning of Curriculum Change

Curriculum workers hold differing concepts of what constitutes the curriculum, and consequently they differ widely as to what constitutes the problem of changing it. In general, those who define the curriculum as the experiences which learners have under the direction of the school believe that changing the curriculum involves changing the factors which shape or influence the learners' experiences. These factors are many and varied. Some are within the school program itself and others are outside. However, there is general recognition that any change in the curriculum involves changes in people. Only as their values, understandings, and skills are changed will the curriculum be modified. Even changes in materials in the school necessitate changes in people. It is from those holding these views that most of the current consideration of the problem is coming.

Those who view curriculum change as a process of modifying the course of study have given little attention recently to the process of change. Thus, while the literature on the curriculum includes numerous suggestions for new courses in general education at the college level, little or no attention is given to the method by which the courses were developed or to the means by which classroom practices can be changed. Occasionally reference is made to such devices as committee work in organizing a new course or cooperative teaching by two or more staff members who represent differing areas of specialization.

There are some who distinguish between broad curriculum policy formation and the immediate tasks of curriculum planning on the local level. Briggs (8) has proposed a commission operating on a regional or national basis which would popularize and develop a basic philosophy of secondary education, propose general curriculums and produce materials that schools can use. Morrison (32) has shown how a state agency could make occupational surveys and do broad curriculum planning for proposed community institutes in New York State.

However, much of the literature describing curriculum improvement practices in state- or system-wide programs has tended to emphasize the importance of the individual school unit or of the participation of all directly concerned with the change. Studies by Devilbiss (13) and Tippett (44) represent examples of this. In a study evaluating aspects of the Alabama state program for curriculum improvement, Nelson (35) stressed the local participation aspects.

Still others, especially the research workers in the Metropolitan School Study Council, have been concerned, among other things, with the community factors which make for change. Pierce (38) has studied the relation between controllable community characteristics and program modification and pointed out possible ways of improving education thru improving the community and increasing community understanding. Mort (33) the research director of the Council, in collaboration with Vincent, has produced an instrument for measuring the adaptability of school systems.

Curriculum Study Agencies Emphasizing Change

As noted in previous summaries of curriculum research, there has been a growing tendency toward commissions or large group projects in the curriculum field. Recent efforts of such groups reveal great emphasis on the methods and means for bringing about curriculum improvement. While the diversity and size of their efforts make it impractical to summarize the work of each, the major approaches which have been used can be noted.

The Commission on Teacher Education of the American Council on Education (1, 2, 39) had as a major function the implementation of what was already known relative to teacher education, and the discovery of means by which groups concerned with both preservice and inservice education could improve the programs with which they are working. The Sloan Foundation projects (36) in Florida, Kentucky, and Vermont, while placing great emphasis on the use of locally-prepared, community-oriented materials, have shown that changes in the school program itself can be made and that these in turn can influence the quality of living in the community served. Somewhat similarly the Southern Regional Studies reported by Ivey (18) have sought to bring about curriculum change thru the introduction of new materials. The California Council on Improvement of Instruction (20) found gains in pupil interest and in the organization of subjectmatter without loss in student achievement thru the use of current materials in seventy-two English, social studies, and science classes. The Southern Association Study (19) in its work with thirty-three secondary schools emphasized the cooperative use of the scientific method in approaching educational problems. Individual schools were aided in using sound methods of studying their own problems and devising their own curriculum adjustment. Use was made of summer conferences or workshops, preschool conferences, regional conferences, and consultant help. Bossing (6) reports a study in six Minnesota schools which started long-term curriculum programs in 1942. While a logically organized program for curriculum study governed the work of the first four years, there was considerable variation from school to school and students, teachers, and lay citizens participated broadly in the program. The Cooperative Study in Education (3) thruout its final report indicates the importance of attention to method and procedure of working if curriculum change is to result. Several other studies now under way are also giving attention to methods for bringing about change.

Process of Change

Miel (30) has made a most useful analysis of the process of change and the necessity for more adequate control of this process. She suggests three characteristics for an adequate process: the guarantee of security for participants, the guarantee of individual and group growth, and the guarantee of accomplishment. Her study also reveals the importance of certain aspects of the process or factors in the process which are subject to manipulation more readily than others at the local community level. These are: (a) the character of the motivations of the persons on whom change depends, (b) the conditions for effective group endeavor, (c) the extent of social invention, and (d) the amount and quality of leadership present.

Interest in the means of change has been very high, especially as it can be furthered thru the group processes. While there have been few research studies published as yet, groups such as the Horace Mann-Lincoln Institute of School Experimentation (16, 31) are studying some of the problems involved. In recent publications this group has provided guides to study and experimentation in cooperative planning, giving particular attention to its purposes and uses, what is known and what needs to be known, and how study can be furthered. Miel (28) has reported how one group studied and analyzed its own working procedures.

There has been a great deal of activity in related fields which has tremendous implications for curriculum change. Organizations such as the Research Center for Group Dynamics at the Massachusetts Institute of Technology, thru the writings of Lewin (21), Lippitt (23), and others are adding significantly to the understanding of group processes and leadership functions as they relate to social change. The Commission of Community Interrelations of the American Jewish Congress and the Classroom Laboratory at the University of Chicago also have studies and experiments under way. Industrial studies, as summarized by Mayo (26) give much support relative to the importance of group goals and group spirit. Steinzor (42) has developed a measure of the motivation or extent of participants in a group discussion. Lippitt, Bradford, and Benne (24) have presented the value of sociodrama in the clarification of leader and group roles as a starting point for effective group functioning. Lewin (21) has summarized studies on the relative merits of individual and group procedures in securing change. He gives the explanation that in certain procedures such as individual instruction the force field which corresponds to the dependence of the individual on a valued standard acts as a resistance to change. When, however, one succeeds in securing changes in group standards, the same force field will tend to facilitate changing the individual. Also, the individual's conduct tends to be stabilized on the new group level. These ideas relative to the importance of the group to which the individual belongs might well be extended to the total environment. It is probable that insufficient attention has been given to the potential educative effect of the environment in inservice education for curriculum improvement. At the present time almost entire reliance is placed on direct instruction. It seems reasonable to suppose that changing equipment, materials, and the total atmosphere might have a much more profound influence.

An interesting related development is to be found in the efforts of the Association for Supervision and Curriculum Development (34) to plan a national conference in such a way as to help its members increase their understanding and skill relative to group procedures. A report of the conference presents an evaluation of this device. In the survey field, Lincoln, Nebraska, has proceeded with widespread participation to study its own program (22). Emphasis has been placed on the making of modifications in program as a result of the staff activity.

Another approach to the problem of change has been made thru studies of obstacles and barriers. Miel (29) studied 440 barriers to improved instruction listed by fifty students in her classes. Several types of analyses of the data were made and possibilities for the use of this device with any curriculum group to discover obstructions were considered. Rouse (41) has analyzed reasons for failure to make changes in connection with the Texas curriculum program. Some of her reasons are worthy of further study. Bradford (7) working in a related field has pointed out bases of resistance to reeducation in government administration.

Studies of the process of curriculum change have not been as intensive and precise as might be desired, but have focused on the participation of all concerned with the process. While any organization of these materials is a bit arbitrary, it seems possible to group them on the basis of primary participants: teachers, lay citizens, and pupils. Each of these will be considered in the sections which follow.

Teacher Participation

Brock (9) in a study of the administrative procedures and practices employed in the development of the core curriculum in a group of selected high schools revealed, among other factors, the importance of cooperative planning by administrators, teachers, parents, and pupils; the significance of intensive inservice education; the value of continued close contact with the community, and the central place of leadership by the principal.

Wetherington (45) has analyzed the way in which North Carolina initiated a state program for inservice education thru the use of workshops. Diederick and Van Til (14) have summarized the principles and practices of the workshop movement. Both reports stress the motivational and action value of starting with problems and needs of participants. Diederick and Van Til stress individual action in respect to the participants' own project and democratic group action as additional important characteristics. Carter (10) in a summary of 100 opinions relative to teachers' institutes obtained thru questionnaire and interview, reveals the institute to be a formalized, ineffective procedure when it is imposed upon teachers without their participation in its direction. He also reveals the importance of the opinion poll as a means of democratizing and vitalizing institutes.

Community Participation

There has been growing attention to the character of the relations between school and community. However, according to Preston and Mulholland (40) most attention has been given to vitalizing the curriculum thru use of community resources or the development of action opportunities in relation to community improvement. Bates (5) has reported on the use of community surveys as a basis for curriculum change. Direct work with adults thru the school has been reported successful. Many other examples of materials prepared for lay citizens may be given, as for example, the 101 practices described by 250 teachers in connection with the work of the Metropolitan School Study Council (27).

Storen (43) has made a thoro analysis of the present forms of lay participation, has related this to current trends in curriculum planning, and has presented problems and suggestions regarding lay activity in curriculum planning. This study has a wealth of suggestions for further investigation in the area.

Howard and Lippitt (17), approaching the problem from the standpoint of group dynamics, have made suggestions which have importance for curriculum workers.

Student Participation

The participation of students in curriculum change is frequently advocated, usually thru teacher-student planning. Studies of the process are not common. Hoppe (15) summarized the literature relative to the theory of student participation in curriculum improvement, and has studied student participation in 110 secondary schools. He reported on areas of participation, technics, methods of selecting participants, and problems and limitations.

Another approach to the problem is found in Baker's (4) study of children's questions and their implications for the curriculum. On the basis of 9000 questions from 1400 elementary-school children, she made suggestions for a problem approach in teacher education institutions. The study implies, however, the use of current pupil interests as a basis for the curriculum. Such interests change with each new group of children. The implication of Baker's study is related to Olson's (37) proposal of self-selection as a principle of curriculum method. He has described the educational applications of the ideas now current relative to self-selection of food by infants.

Research Needs

Obviously much further research is necessary if problems of curriculum change are to be fully understood, but even more important new research technics are probably required. Charters (11) contrasted the approach in which a research staff carries on the studies, with that in which each faculty member, interested in self-improvement, receives the stimulation and assistance of the research staff. Stephens College has operated on this latter plan since 1921. Cunningham and Miel (12), Lippitt (23), and Mackenzie (25) have indicated the need for cooperative action research if many of the problems of curriculum change are to be better understood and controlled. Many of the current uses of action research in industry, government, and community affairs hold significant promise for curriculum workers. Current investigations in the areas of group dynamics and human relations are closely related to those problems of curriculum modification which involve changes in people and which are receiving current emphasis.

Cunningham and Miel (12) have listed some of the problems of curriculum change on which research is needed: (a) getting initial interest in curriculum change, (b) improving attitudes toward change, (c) dealing with the phenomenon of crystallization, (d) managing the helps and hindrances to curriculum change which teachers recognize, (e) using leadership to further curriculum change, (f) using the expert to further curriculum change, (g) organizing for curriculum development, (h) improving the quality of cooperative planning, (i) improving communication, (j) improving human relations, (k) securing appropriate materials of all types, and (l) technics for developing a common philosophy among all people concerned. Undoubtedly this list could be extended. Obviously many factors are interacting to shape the curriculum. If changing the curriculum involves changing these many factors or at least modifying their interaction, curriculum change becomes a very complex problem. The idea that change of the curriculum can be controlled and directed is being approached in new ways, and the ultimate extent or speed of change is not yet clear. However, the means for effectively and rapidly improving the curriculum is one of the most significant areas for current investigation.

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CHAPTER VI

Curriculum: Library Resources

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Introduction

PART II of the Forty-Second Yearbook of the National Society for the Study of Education, entitled *The Library in General Education*, is after five years one of the most useful discussions of the values and functions of the library now available. More recently Mishoff and Foster (40) issued a useful bulletin of public library statistics which gave the status of public library service thruout the United States. Fargo (19) described the school library, the bases for its administrative and financial support, and some of the approved methods of functioning. Cole (11) edited *Library Literature*, an annotated index to 1946 publications concerning the library profession. *Library Literature* is an annual publication, which, because of the war, was suspended for three years, 1943-1945. It is planned soon to make up these arrears in the indexing of books, theses, periodicals, and pamphlets dealing with the library. Library research for 1942, 1943, and 1944 was surveyed in the June 1945 issue of the REVIEW.

General Character of the Research

Scientific research is a relatively new development in the library field, having been postponed by World War I and interrupted by World War II. There are only a few well-established graduate library schools. Cole (12) made a study of the graduate theses accepted by library schools in the United States from July 1938 to June 1945. Cataloging and classification was the field of investigation most frequently chosen by library school students. Descriptive bibliography ranked second. The largest number of theses were written in these two fields. The areas of government, administration, interpretation, and evaluation included but a small number of the theses. These were the fields of library research which Cole judged to be of prime importance, yet they are most seriously in need of factual and theoretical literature. Cole also classified 727 theses written since 1928. The years of greatest research were those immediately preceding our entry into World War II, 1938-1941. The peak year was 1940.

The library literature for 1945, 1946, and 1947 contained little of formal research, but there were selective and annotated bibliographies, service studies on a local and regional basis, and a few important surveys.

Surveys, Standards, and Evaluation

The National Opinion Research Center (42) studied the functioning of the public library as a personal service organization and as a civic institution. The survey was conducted in seventeen cities, and 2114 persons (all over twenty-one years of age) were interviewed. Two out of every five adults reported reading as a favorite diversion but only 25 percent made use of libraries. Those interviewed knew little about the services which public libraries rendered other than those of lending books.

Orton and others (45) studied the adequacy of New York City's public library system. Among their many recommendations was one to the effect that economy dictated that the public libraries should do all the library work for schools, except in those areas where a branch library would not receive sufficient community use to warrant its maintenance. This recommendation is questionable in view of successful experience with school libraries in New York City and thruout the rest of the country. It appears to need substantiation by research in the light of modern educational objectives. The New York State Education Department (43) reported in 1946 that 1,500,000 citizens of New York State had no public library available for local use, and that another 2,000,000 were served by libraries with inadequate book collections and with inadequate facilities for rendering essential library services. In another study of the New York State Education Department, Beck (6) surveyed the library services which the people wanted. A similar study of library adult-education aims was carried out by Spence and O'Brien (46).

Grady (22) inquired into the services of libraries of teacher-training institutions. Altho demonstration-school libraries were found to be superior in general to the average school library, they did not meet his suggested standards. The American Association of Teachers Colleges (1) developed qualitative standards for teachers college libraries, and made suggestions for their evaluation.

The American Library Association (3) evolved standards for school libraries as to staff, resources, quarters, and administrative plans, in relation to the program of the school. Douglas (15) set forth recommendations for the school library with respect to personnel, book selection procedures, and physical facilities.

Administration, Teaching, and Related Services

Fargo (19) drew from many studies and pooled the results of successful experience to state the problems of library organization, administration, instruction, and servicing. Her description of modern educational patterns and library aims is clear, helpful, and compact. Batchelder (5) analyzed the obstacles to satisfactory library services for rural children. She outlined the programs for rural library service in several of the states. Dodd (14) described the library service in the graded elementary and secondary schools in the rural towns of three counties in Minnesota. Hayner (27) predicted the regional organization of school libraries. Lamb (33) studied the services of the secondary-school library in library-study halls. Heller (28) described the book selection practices in one secondary school.

Fenner's publication (20) provided practical answers to many problems of library management in the elementary school. Walraven and Hall-Quest (49) issued a compendium of information on the use of the elementary-school library in teaching. Fargo (18) described a method of initiating and conducting learning activities which center in or depend upon the library. Brown (10) issued a manual on the use of the library in which she assembled much helpful information for students and teachers. Henne and Pritchard (29) furnished an account of a cooperative program planned by a teacher of home economics and a librarian.

Wilson and Tauber (51) conducted a comprehensive study of the university library, its organization, administration, and program. Lyle and others (37) published a book on the administration of the college library, which for the first time gave data on comparable institutions. Swank (47) investigated the organization of library material in respect to its worth and practicability for research in English literature. He studied the card catalog and shelf classification at the University of Chicago library to determine their value in locating research material. Swank found that published bibliographies or combinations of such bibliographies produced better results than the library catalog and classification. Swank's study suggested that some of the money now spent on cataloging be used to purchase additional bibliographic materials.

Bibliographies

Eaton (16) prepared an annotated list of books for boys and girls of prereading age thru high-school ages. Eaton's purpose was to aid boys and girls in building personal libraries. Howard and Lundeen (30) issued a list of books for retarded readers. Reading levels covered were grades one thru seven. Interest levels included grades one thru twelve. They also reported a list of books for teachers of children retarded in reading. Brooks (9) edited a bulletin which reported the results of an analysis of children's books at the University of Chicago. The analysis was made on the basis of the developmental interests of children. The books were tested at the Graduate Library School and in the laboratory schools of the Department of Education.

Bedinger (7) put forth suggestions for the selection of books in science for the small library. The suggestions were drawn from experience and not from scientific investigation.

Trager (48) examined twenty-two lists of children's books concerned with intercultural education. These books ranged in interest levels from preschool thru junior high school. Criteria were studied, and finally twelve specific criteria were used in selecting the books. Of the 253 titles examined, seventy-one were accepted and listed. Since the 253 titles did not include all the books in the twenty-two lists, the reader has no way of knowing which books (other than the seventy-one accepted) were examined or which books were rejected. The American Council on Education (2) issued a bibliography on intercultural education, entitled "Reading Ladders for Human

Relations." The methods of book selection were explained. Eight areas of human living were explored, and books listed under each. The "reading ladders" were intended primarily for the schools that cooperated in the project.

Reading and Reading Guidance

No attempt is made here to review any large amount of the research in reading for 1945, 1946, and 1947. A few references of special significance to librarians, particularly school librarians, are included.

For a number of years Gray (23, 24, 25, 26) has issued in February a summary of reading investigations completed during the twelve months ending the previous June 30. These were published in the *Journal of Educational Research*. Gray's 1945 summary (23) should be of special interest to librarians, since it listed studies of library coverage and others in the hygiene of reading.

Leary (34) summarized some of the results of reading research. Findings pertinent to the library were: (a) Library card holders in an ordinary town with a library comprised less than 30 percent of the population. Half of the card holders were children. (b) Expenditures for the library and reading tended to lag behind all others. (c) Pupils in the elementary schools showed "a discouraging lack of familiarity with good current books." (d) The comprehension level of persons twenty to forty years of age was placed at slightly above seventh grade.

Arbuthnot (4) surveyed the reading interests of children from two to fourteen years of age. She covered every type of book other than textbooks. Criteria were set forth for all types. Lucas (36) analyzed thirty third-grade readers to find out what fables, fairy tales, folk tales, myths, and legends were included from 1887-1946. Maguire (38) did much the same for thirty fifth-grade readers, 1890-1945. Norvell (44) published a preliminary report of a twelve-year study of children's reading interests. The sources of data were 1,590,000 reports from more than 50,000 pupils and 625 teachers in all types of communities in New York State. Norvell showed how pupils' choices were affected by factors such as age, maturity, sex, and intelligence, and stated the implications of the study for classroom practice. Elder (17) reported an investigation of the relationship of the school library to the remedial reading program, based on the replies of 101 school librarians to a questionnaire. Her report described the criteria for selecting materials for slow readers with varying handicaps and inabilities.

Link and Hopf (35) had 235 interviewers canvass 4000 young people and adults to ascertain their reading and book-buying habits. Interviews took place in May and June of 1945 and there were a few check interviews. About 70 percent of all book reading was done by 21 percent of the population. The number of years of formal education was mostly closely associated with amount of reading. Socio-economic status came second.

They concluded that best-seller lists were not reliable indexes of the number of people who read the books.

Kircher (31) compiled a list of books suitable for children in connection with a project conducted for the Children's Library at the Child Center of the Catholic University of America. The books were annotated with respect to their values as character building agents. This project was designed to supplement the research of Moore (41) into the need for children's books in the application of bibliotherapy to the problems of childhood. Moore reported his study of the effects of reading on conduct.

Berelson (8) collected data from 600 residents of Erie County, Ohio, to determine political differences between library users and nonusers. He found that his subjects selected their reading to lend support to their opinions rather than to modify or change their predispositions. His conclusion was that this condition seriously limited the psychological and social effects of reading.

Martin (39) made use of several studies on the use of magazines to make suggestions concerning periodicals for school libraries. In this latest edition, she included for the first time a consideration of magazines for elementary schools and a summary of contemporary studies of magazines for children of elementary-school age.

Audio-Visual Aids

Glavin (21) pointed out that the educational film is now recognized as an important tool for public libraries in the recording and transmitting of knowledge and ideas. Glavin presented information to assist public librarians in the establishment of film programs. His recommendations should also be helpful to school and college librarians.

Kohberger (32) reported an experiment in radio story-telling carried out by the Carnegie Library for the primary grades in the public schools of Pittsburgh.

Education for Librarianship

Wheeler (50) studied the education of librarians for all types of libraries. He stressed the need for greater consideration of inservice education in view of changing needs. Danton (13) inquired into many phases of education for librarianship and recommended that the curriculum be differentiated for the type of library which the prospective librarian planned to serve.

General Implications

The question of the administration of the school library has again been raised. This issue was apparently settled by a number of studies of which the report of the Joint Committee of the National Education Association and the American Library Association is representative. (See June 1942 Review.)

New studies should be made to give interpretation to the needs, purposes, and legal structure of the school library in the light of modern educational objectives. The financial support of public and school libraries has remained tenuous. Research is necessary to settle the question of adequate means of support.

There is the issue of what unique services the school library can best perform. There are phases of reading instruction which might be more suitably handled in the school library than in the classroom. Experimentation and reports of practice are needed in the coordination of the auditory-visual aids program with the library services.

The library schools are in a period of rapid and profound change. Curriculums are being revised. New courses and new emphases in old ones are being formulated. Research should be carried on to guarantee that these changes be genuinely related to the objectives of American education.

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INTRODUCTION

This issue of the Review covers research in the teaching of science and mathematics thru the interval from May 1945 to May 1948. The last two previous issues dealing with these subjects were the October numbers of 1942 and 1945 (Volume 12, number 4; Volume 15, number 4). In both of these issues the reviews were classified according to the grade level to which the research was related.

The committee responsible for this issue has favored grouping the summaries of research according to the purposes with which the investigators were concerned as they entered upon their work. The four main categories are (a) aims and purposes, (b) methods and materials, (c) measurement and evaluation, and (d) teacher education. Reviews appropriate to the category in each of the administrative divisions of the school have been brought together. This arrangement was made to help the reader recognize the common problems of investigators working with children at different levels of maturity. It will help the critical reader to discern the trends and to see in what particulars the different investigators are guided by theories derived from common, as well as from conflicting concepts of values. For example, the chapter on "Aims and Purposes of Science Teaching" makes it clear that some investigators—especially those working with younger children—recognize in the theory underlying their studies the values to be derived from (a) education for emotional development, (b) education for skill in the democratic processes, and (c) recognition of children's needs and interests as revealed thru studies of growth and development. Other investigators have been guided by theories of learning for understanding, by theories that favor differentiating young people on the basis of certain skills and abilities, and by theories derived from concepts of disciplinary or transfer values. The reader will be assisted in his criticisms of current theory and of technics and trends in research when these different and often conflicting efforts, directed toward the same general purposes, are brought together. This is, indeed, the main argument for bringing together reports of research in which elementary-school children are the subjects of study with research and reports in which young people of greater maturity are the subjects.

The collaborating authors of the first five chapters of this number were selected and assigned so that one would be primarily concerned with work with elementary-school children and one with work with students on a more mature level.

It will be recognized at once that any classification of the reviews must be more or less arbitrary and by no means discrete. This is evidenced in this issue by the fact that authors of chapters with different titles have, in a few instances, referred to the same studies. This duplication of titles in different bibliographies may seem objectionable but if these reviews are to be properly interpretative, some duplication can hardly be avoided.

There will be interest in contrasting the studies of aims and purposes in both science and mathematics that are reviewed in the chapters with this title with the studies reviewed in the chapter on measurement and evaluation. In the former there is clear effort to define aims and purposes with recognition of immediate usefulness and of continuity toward independence in learning and working. In the chapter on measurement the studies reviewed are concerned with measurement of factual learning, with problem-solving ability, with generalizing, and with applying principles, but mostly within the framework of teacher-controlled situations with neglect of evaluation of progress toward intellectual independence. Experimentation in education based upon educational theories derived from the philosophy of experimentalism has hardly yet been undertaken. Investigators in the area of measurement and evaluation will no doubt find suggestions for further fruitful research from closer examination and study of theory and practice in curriculum development.

The amount of research in the teaching of science and mathematics during the interval covered in this review seems larger, except possibly in the area of teacher education, than that of the previous three-year interval and comparable to the amount reported in an equal time interval before World War II. There seems to be reason to believe, however, that fewer of the research studies recently submitted to meet requirements for degrees are being published, and that fewer of the published studies would be regarded as particularly meritorious.

A large share of the responsibility for assigning and for assembling the summaries of research in teaching mathematics was assumed by William A. Brownell. In carrying forward this phase of the work, Dr. Brownell has in effect served as co-chairman.

SAMUEL R. POWERS, *Chairman*

CHAPTER I

Aims and Purposes of Science Teaching

N. ELDRED BINGHAM and JOE YOUNG WEST

RESEARCH workers examining the elementary-school science curriculum have found evidences of real concern for the emotional development of children, for democratic living, for the difficulty experienced in grasping science concepts, for the place of children's interests in building programs, and for the evaluation of the results of instruction.

Science in the Elementary School

In the attack of the Institute of School Experimentation (31) the "shortage areas" are of particular interest to science educators. There seems to be little uniformity in the results from the various interest studies. Blough (10) and his committee projected needed research in science teaching in the elementary school. The Science Committee of the National Society for the Study of Education in the Society's Forty-Sixth Yearbook, Part I (54) gives what is perhaps the clearest picture of the trends in science in the elementary school. In this yearbook the objectives of science teaching were defined, and a continuous integrated program of instruction in science was recommended.

Arisman (3) pointed out that education is a process by which changes are effected in people. He developed general criteria for meeting the emotional needs of children in the classroom. Workers in the field of elementary science should profit from the analyses of the concepts formulated.

Baker (4) analyzed third- to sixth-grade children's questions collected from a wide variety of localities in the United States. Since no categories were imposed, there was freedom for questioning. Fifty percent of the questions were in social studies, nearly 38 percent were in natural sciences and the remainder in various other fields. Surprisingly enough, barely 4 percent of the questions were related to the local community. Tho like in kind, questions by girls were more numerous than those by boys. Many interests seemed to run concurrently, and within a given area might be expected to continue for several years. The children were interested in origins and causes of natural and social phenomena. They wanted help in interpreting the facts and situations they observed. According to the investigator, in order to meet the needs of boys and girls, teachers need a rich background in the social studies, and in the biological and physical sciences, as well as information on current affairs.

Drill (19) in another study on children's interests in science, attempted to obtain reasons for interest in certain topics. On the basis of 47,330 contributions submitted by 10,453 children the following conclusions were reported: (a) Forty percent of all the contributions thruout the grades indicated interest in science phenomena. (b) Thruout the grades boys showed greater interest in science than was shown by girls. (c) Children in this study were more interested in individual plants, animals, machines, or units of the physical environment than they were in societies of organisms in relation to their environment or in the stars, moon, sun, and the planets. (d) A slight advantage was shown in favor of biological sciences over the physical. (e) Kindergarten and seventh- and eighth-grade groups showed keenest interest in maintaining health, while the middle groups were more interested in intellectual pursuits. (f) Children occasionally showed some understanding of a scientific principle. (g) The season had some effect on the children's choice of topics, particularly of younger children.

Von Qualen and Kambly (70) investigated the science interests of fourth- to sixth-grade children from their choice of reading materials. They found a wide range of interests. Girls were least interested in plants, astronomy, earth's crust, magnetism, and electricity. Boys showed least interest in conservation, cloth, astronomy, weather, plants, light, and earth's crust. All pupils were most interested in ancient animals, science and industry, transportation, and living animals.

Paterson (57) used pictures in a study of the science interests of children in Grades IV to VI in three different environs within a city. His method of obtaining data on interests appears to be a promising one.

Hill (27) studied the appropriateness of objectives in science teaching proposed in the Forty-Sixth Yearbook of the National Society for the Study of Education Part I (54). Data were collected from Grades I thru VI by recording remarks verbatim and by recording responses into categories representing the accepted objectives. The following conclusions were stated: (a) The objectives listed in the Thirty-First Yearbook were appropriate goals in elementary-science instruction. (b) Children should be given more opportunity to engage in activities pertaining to responsibility, cooperation, initiative, and application of experience and skills. (c) The number of responses that children made did not increase from one level to another tho some recognizable differences were evident in the quality of the responses. The investigator urged educators to redefine objectives in terms of the relative excellence of response from children at various age levels.

In an examination of the explanations of scientific phenomena made by children, Oakes (55) found that the majority of their explanations were naturalistic, that children can learn correct explanations of many natural phenomena, that understanding of essential relationships increased with age among children, and that bright children are more likely to give physical explanations than the less bright. Oakes (56) also reported that where the correct concept is lacking, the explanations of adults did not differ materially from those of children.

Pella (58) analyzed the five most widely used textbook series in elementary science to determine the areas included, the topics discussed, and the concepts presented in each area without reference to grade levels. He reported that there was a fair degree of agreement in the five series as to the areas included. There was relatively little agreement among the topics discussed, and an extremely small amount of agreement among the concepts developed. There was a greater variation in the grade placement of the concepts than in the concepts presented, tho only 1464, or 16 percent, of the 8913 different concepts appeared anywhere in four or more of the series of five textbooks.

Science in the Junior High School

There have been considerably fewer studies made and less writing on the organization of courses of study in junior-high-school science than in other phases of the science program. There seems to be more confusion and lack of organization at this level than at any other. However, the following principles seem to have general acceptance: (a) science curriculums of junior high schools should be organized in harmony with elementary- and secondary-school programs; (b) the science program for the three-year junior high school should be organized into a unified sequence of experiences; (c) the material should be organized into large environmental units, and each unit should deal with worthwhile life problems, divided into significant subproblems which have significance for the pupils.

Glenn and his committee (25) proposed a number of important directions for research at this level. Among the questions proposed were the following: (a) What is a desirable sequence and time allotment for general science in the junior-high-school grades? (b) What elements of the scientific method and what attitudes can be taught so as to function in the lives of the junior-high-school pupils? (c) What are some principles basic to the effective use of multisensory aids in teaching junior-high-school science? (d) To what extent is pupil planning feasible in determining content and procedure for junior-high-school science courses? (e) To what extent do pupils evidence readiness for the more advanced science concepts? (f) Can the feverish, scattered pace of junior-high-school science be slowed down and be made more thoro? (g) Can a textbook be written which will avoid reducing the course to a review of elementary work, or a vocabulary-ridden sketch of high-school work?

Bissiri (8) investigated the present status of the natural science curriculums in junior high schools thruout the country and established criteria for evaluating them. He found the small amount of time given to science in many junior high schools and the lack of evaluation particularly alarming and concluded that present junior-high programs do not meet the needs of pupils. He proposed that curriculum committees should survey what is being done in other educational centers, then define their own criteria for organizing science offerings, and that subjectmatter should be selected to meet present and potential needs of pupils, to meet different levels of ability, interest, and maturity.

Leonelli (43) determined the principles of physical and biological science found in eighth-grade general science textbooks. Case (13) determined the principles and experiments of physical and biological science found in ninth-grade general science textbooks. Whitman (72) made a study of the truthfulness of weather proverbs in terms of scientific principles. Hilty (28) investigated the lives and works of eminent men and women in several fields of science with particular regard to the part played by reflective thinking in their researches.

Smith (62, 63) tested the hypothesis that specific items of science information have a fixed difficulty for various populations, by selecting and teaching significant subjectmatter to groups of ninth-grade pupils. Appropriate tests were devised, standardized, and administered. Important findings were: (a) the difficulty of tested items varied as much as 50 percent when conditions and amount of exposure were varied; (b) the difficulty of the sampled items was too great for the average ninth-grade pupil to master with 50 percent success under the conditions of the experiment; (c) the most important factor in success in learning general science information was the selection of items of content; (d) variations in method and amount of exposure rank below the type of material and differences of ability; and (e) the abilities measured by mental tests and indicated by IQ are not necessarily the major abilities involved in learning general science material.

Science in the Senior High School

There is evidence of a continuing emphasis on defining and meeting student needs at the secondary level. This is found in both the authoritative reports and the researches. In the Forty-Sixth Yearbook, Part I of the National Society for the Study of Education (54) emphasis was placed upon problems of social significance which may be found in such broad areas of human experience as health, consumership, conservation, vocation, family relationships, and citizenship. Stratemeyer and others (65) stressed as the basis for a modern curriculum the characteristic life situations which are faced by learners. In the Eighth Yearbook of the John Dewey Society, Corey (17) directed attention to the developmental tasks of youth as the major goals of secondary education. These developmental tasks are outlined as (a) coming to terms with their own bodies, (b) learning new relationships to their age-mates, (c) achieving independence from parents, (d) achieving adult social and economic status, and (e) acquiring self-confidence and a system of values. With but minor exceptions, the researches show trends in keeping with the philosophy expressed in the above reports.

Robertson (60) studying the secondary schools of Ohio, found evidence that the widely employed subjectmatter approach has failed to accomplish the desired objectives of modern education. In most schools the concern for the democratic way of living is low; teachers are operating according to outmoded psychological doctrines; adolescent needs, interests, and problems, as well as the community and its needs, are generally ignored.

Using a questionnaire previously developed by Hunter and others, Ahrens (1) and Hunter and Ahrens (32) summarized the objectives of science teaching in the secondary schools of California and revealed the shifts in these objectives which have occurred since 1940. An understanding of the environment holds first place in the junior high school, but the scientific method ranks first at the senior-high-school level. At both levels the scientific method, together with the attitudes and technics of the scientist increased in importance. While the functional group of objectives has decreased in importance, emphasis has been placed increasingly upon factual science material and upon preparation for college. This trend can be accounted for in part by the war. In spite of the fact that current educational literature stresses repeatedly the functional needs of youth as a basis for the curriculum, the evidence from this study shows that these needs are not being met. However, the pattern of science teaching follows more closely the newer concepts of child growth and development. Concepts and generalizations are developed by taking objective realities, using them as a problem, and then solving the problem. Ahrens concludes that science teaching must relate more closely than in the past to the material and social aspects of life.

The following studies show clearly that personal and social needs of pupils, rather than subjectmatter goals, should be stressed. Alpern (2) devised and administered tests to determine the degree of ability of a selected group of high-school pupils to test scientific hypotheses and to evaluate certain measurable factors related to this ability. Conclusions show that this ability to suggest procedures to test hypotheses depends in part upon the habit of delayed response, an element of the scientific attitude. He failed to find a significant correlation between the ability to select procedures to test hypotheses and chronological age, intelligence or reading grade. Keeslar (37) made an analysis of literature concerning the scientific method which could be used for instructional purposes in secondary schools. The list was checked by twenty-two research scientists. Current opinion to the contrary, the investigator found that the elements of scientific method are definite, distinct from scientific attitudes, and are known and used by scientists. He suggests that high-school teachers using this list might help pupils to find and solve everyday problems. Likewise in a survey of research studies dealing with the elements of scientific method as objectives of instruction in science, Keeslar (38) found that research workers often confuse scientific method with scientific attitude.

Weisman (71) reported that the development of understanding of scientific method at the secondary level is a legitimate objective. He attempted to determine experimentally whether or not the ability to interpret data can be improved by an experimental method in which the desired thinking outcomes are set up as definite aims of instruction. Six biology classes were taught by the investigator using the experimental method, while six were taught by teachers considered equally good who thought that critical thinking would develop concomitantly as students followed the regular course of study. Results obtained after a year's instruction and again a year later demonstrated that the ability to interpret data can be significantly improved by the procedures used in her study. Rather than emphasis on memorization of facts and principles, the objectives of instruction become the recognition of assumptions, proper qualification of conclusions based on sampling, cautious use of predications, and care in drawing reasonable conclusions and in applying them to new situations. To realize the implications of the study would necessitate a thoro reorganization of the science curriculum around student interests and needs in the basic aspects of living and functioning in their own community. It further implies a change in both the curriculum and method of teacher education.

Since the ability to apply the principles of physics to practical out-of-school situations is one of the major objectives of instruction in high-school physics, Wise (73) investigated the relationship that exists between ability to recall information and to solve conventional problems, and the ability to apply principles in the solution of problematic situations typical of out-of-school experiences. He found that the abilities are not identical; both abilities are related to intelligence to about the same degree; and that grades are not a valid measure of either ability.

In a study of scientific inquiry in textbooks, Lampkin (40) revealed wide variability among carefully selected judges. Using multiple-factor design, twelve textbooks (three each from general science, biology, physics, and chemistry) were broken up physically and rearranged into twelve composite textbooks, each to be read by one of twelve readers, six with background in science teaching and six with background in philosophy. It was shown by analysis of variance technic, supplemented by two independent tests, that the readers varied not only on what aspect of scientific inquiry was referred to in certain statements, but also on whether any aspect was referred to. The following are some of the possible inferences from the data on reader variability: (a) The task of analyzing textual material for conceptual content is extremely difficult. Earlier studies of textbooks and related materials should be reviewed from this standpoint. (b) The readers projected their own ideas into what they read. (c) Where applicable, multiple-factor designs should replace single-factor designs in much educational research.

Evans (21) implemented the social needs approach by arraying the procedures one would use in the study of a community problem such as health.

By a survey of the literature, McKibben (51) investigated the relative values of the general objectives of biology for general education, together with the changes that have occurred in the last twenty years. Knowledge, scientific method, health, economic, and general application objectives headed the list twenty years ago as today but now there is more emphasis than formerly upon the economic and social objectives. McKibben concluded that biology, to be of greatest value to the individual and to society, should emphasize the practical and the social to a greater extent.

Lurensky (45) investigated the applications of principles of biology in high-school biology textbooks. Eastman (20) attacked the problem of determining topics suitable for developing understandings of physical-science principles in a senior-high-school chemistry course, and Lovely (44) determined topics suitable for developing understandings of biological principles in senior high school.

Katz (36) studied the role of the textbook in developing a mastery of biology and in thinking. Analyzing specific texts according to certain criteria, he found certain texts superior with regard to the definition of words, while others presented problem material in a way that more effectively promoted scientific thinking.

Klise and Oliver (39) procured student reactions from their own biology classes. Certain units proved more popular than others, but the popular units were different for the two investigators. Among the results were student requests for more field trips and for more experiments or laboratory work.

Subarsky (66) experimenting with a group which possessed little racial prejudice, found that by providing for two integrations of biology and social studies during a term, one integration centering around physical and cultural development, and the other around human group relations, greater changes in racial attitudes were produced than by conventional courses in these subjects.

McGrath (50) investigated the relative significance and use of chemistry principles and generalizations in the general education programs of a selected group of high schools. Using the jury method to establish the relative significance of the principles and generalizations, he found a close agreement between the principles in use in the schools and those deemed significant, altho the jury of specialists would add principles and generalizations concerning the topics—sulfur, equations and problems, and the halogens. Those deemed of significance for general education include the portions of such topics as introduction to chemistry, atmosphere, oxygen and hydrogen, water, carbon and fuels, and chemistry and health that deal with practical everyday phenomena. Technical topics such as atomic structure, equations and problems, and the more difficult parts of metallurgy tend to be avoided.

In an investigation of the reasons for the election and nonelection of chemistry by high-school pupils, Murphy (53) found that boys and girls wish to learn more about occurrences in everyday life and the composition of the things they use daily. They also wish to work in a laboratory and to see demonstrations. He concluded that the course of study should emphasize those aspects of chemistry that are related to the ordinary life of high-school pupils.

Two studies of physics textbooks were made, one by Perkins (59), who determined the extent to which the names of scientists are included in textbooks, the other by Benumof (6), who found that modern electrical communication is treated to a very slight extent in both high-school and college physics textbooks; that but two-fifths of the high-school physics teachers and but one-half of the college physics teachers mention or describe these modern developments, tho a larger proportion favor their inclusion. The modern developments include the Giorgi system of units, field theory, wave propagation, new generators, new resonators, crystals, wave guides, directional devices, microwave measurements, frequency modulation, facsimile transmission, automatic telephony, and television. Benumof proposed that the topics of electricity, light, and sound in elementary physics be enriched thru a descriptive treatment of recent advances in electrical communication.

Barnard (5) told of the desire of a committee of the National Association for Research in Science Teaching for research in secondary-school science to promote research in problem solving. Johnson (33) described the science-education research that is underway in the secondary division of the United States Office of Education.

The pre-war tendency toward a fused physical-science course is supported by the Committee on Science Teaching of the National Society for the Study of Education (54) and by the Cooperative Committee on Science Teaching of the American Association for the Advancement of Science (16).

By using a jury of specialists, Miles (52) determined the relative importance of the principles of physical science which are desirable for inclusion in an integrated course of physical science for the senior high school. He also determined the relative values of the experiments which are desirable for inclusion in such a course, and whether each of those experiments would more appropriately be done as a laboratory experiment or as a demonstration. Of the forty principles deemed essential by all the specialists, twenty-six were in physics (including astronomy and meteorology); eleven in chemistry; and three in geology. From the extensive list of experiments assigned to the forty principles, 125 were considered by all the specialists to be either ideally or well-suited for such purposes. Anyone responsible for the development of a physical-science course should read Miles' thesis.

Science for General Education at the College Level

McGrath (50) in an introductory editorial dedicated the new *Journal of General Education* to the goals of general education in colleges and universities. Among the salient features of the general education movement are (a) a reaction against specialism and vocationalism, (b) an effort to integrate the subjectmatter of related disciplines, (c) an attempt to assist differences between the deficiencies of college students and the deficiencies of a ninth-grade group in high school. Analysis of the nature of errors revealed a need to institute a remedial program in higher educational institutions. Kinzer and Fawcett (23) similarly found important arithmetic weaknesses in beginning chemistry students as measured by a placement test. Eshbach (11), Nielsen (31), Hayes (18), and others pointed out the inadequacy of preparation in mathematics by college engineering students, and they also emphasized the need of greater articulation between mathematics and engineering.

Burton (5) described the beneficial effects of a remedial program in high school. Kinzer and Fawcett (23) reported the improvement in arithmetic by college chemistry students as indicated by a retest following three weeks of remedial instruction. In a follow-up of these same students Kinzer and Kinzer (24) reported a correlation of .52 between the retest grades and college chemistry grades.

In study of causes of deficiencies in mathematics among high-school and college students a variety of factors have been investigated. A committee of the Association of Mathematics Chairmen of New York City (1) found fifteen factors significantly associated with failure including personal habits, out-of-school activities, and lack of interest. Holzinger and Swineford (19) investigated the predictive value of the spatial and general deductive factors of a test given to eleventh-grade geometry students at the beginning of the year. The test included eight spatial tests and three additional tests of ability to separate the spatial factor from the general factor. The scores on all eleven factor tests had a correlation of .768 with the geometry achievement test given at the end of the year. Torrance (39) found a relationship between performance on selected items considered important for mathematicians from the *Strong Vocational Interest Blank* and the mathematical achievement of those in the top 10 percent of interest and those in the bottom 10 percent of interest. Only three of the top fifty had ever failed mathematics, and only four of the bottom fifty had escaped failures in mathematics. Cattell (7) made a study of the relationship between mathematical abilities and personality data taken from carefully controlled ratings on thirty-five personality trait clusters "known to be representative of the whole personality sphere." The subjects were 123 adult males in the Army Student Training Program. When the effect of intelligence and of ability on the *Graduate Record Examination* was partialled out, the correlations of mathematical ability with individual personality traits were practically zero.

A general overview of the research in the area of mathematical deficiencies in high school and college lends weight to Buswell's (6) suggestion that there is need for greater emphasis on research relating to procedures for correcting and preventing computational difficulties as compared to that directed to discovering and defining deficiencies.

Attempts to define desirable outcomes for mathematics have continued along two major lines:

1. Surveys of mathematics required for adult usage—nonvocational, vocational, and college. Few of these studies have investigated the level of proficiency required for personal efficiency.
2. Studies of deficiencies existing among high-school and college students, with some attention to causal factors and remedial procedures.

Prevey (33) studied the relationship between childhood experiences with money and later use of money, and, also, between responsibility which children are allowed to assume in the use of money and their general level of adjustment during high-school years. Some relationship was found in both cases. Thorndike (38) found that grades in general mathematics are more predictive of grades in physics than are geometry grades. In a study of students entering a state university without credit in high-school mathematics Benz (2) found that about half were on probation at some time and only about one-fourth eventually graduated.

Russell (35) studied decimal usage in the occupational world, surveying 68,000 persons in eighty-nine industries. The majority of the employees had no need for percents. Seventy percent of the census classifications reported that less than one-tenth of their populations used decimals. Sutton (37) reported a questionnaire study in which responses were obtained from sixty-nine secondary and college administrators and teachers after they had participated for one summer in the Chrysler Corporation work program. This program consisted of work in the factory and a series of conferences. Responses to the questionnaire indicated that while the average worker uses little science or mathematics, advancement frequently depends upon both.

Research for this period further verified the mathematical deficiencies previously described in pupils at all high-school levels, as well as the college-freshman level, and in certain specific college courses. Rausch (34) found that retention of a computational skill by teachers was directly related to the use they made of it in their field of specialization. Ebert (10), investigating the ability of eighth-grade pupils to achieve mathematical generalizations, found significant relation between generalization and mental ability and between generalization and reading ability. Guiler (12, 13, 14) found that a large percent of the ninth-grade students were incompetent to deal with percent and to handle decimals and common fractions. Ohlson (32), in studying achievement of students in Grades X, XI, and XII, of forty-three Iowa high schools, found that the present program is equipping less than 50 percent of the students with needed mathematics in a wide range of detailed areas.

Guiler (15, 16, 17) studied the deficiencies of college freshmen in common fractions, decimal fractions, and percents and found no important quality of the performance of children with eight-months attendance in nursery school and kindergarten was superior to that of those without school experience. In a second study Mott and Martin (29) interviewed sixty-six first-grade children, who previously had been tested at the end of the kindergarten year, to see whether first graders retained the number concepts learned in kindergarten. Only in rote counting in the higher decades did the children show loss after a lapse of three months in number training. The writers attributed the retention to the fact that young children need and are using numbers in their home environment.

Stotlar (36) studied the number concepts of nineteen children (ages fifty to sixty-nine months) one year before beginning formal instruction. She found no marked difference between skill in rote counting and in forming number concepts and concluded that both advanced at about the same rate. The studies reported in this section tend to confirm the growing conviction that readiness for learning number ideas and skills is primarily the product of relevant experience and not merely the effect of becoming older.

Davis and Rood (8) sought to find the extent to which pupils retain certain basic computational skills while studying the increasingly complex materials of the upper grades. The progress of fifty-six pupils entering Grade VII was studied over a two-year period by means of a series of five tests. The writers concluded that one cannot assume that an ability once demonstrated will remain at the same height of efficiency even during a short period of four months. Recovery of abilities is easier immediately after loss than at later periods.

II. Secondary and College Mathematics

Kinney (22) set up certain criteria by which objectives may be appraised both for purposes of selecting activities and content and for purposes of evaluation of outcomes of instruction in high school and college mathematics. Kilbridge (21) utilized an interesting procedure to obtain a statistical check on the classification of the objectives for the comprehensive examination in Mathematics 1 at the University of Chicago. He also experimented with a method for checking the discreteness of the objectives of the course. The objectives implied in the test items were compared with the objectives set up by the authors. The two sets of objectives thus obtained were found to be about the same. Correlations between problem responses in the areas of various objectives revealed that ability to solve elementary problems correlated .78 with ability to use fundamental ideas of space, number, and logic in algebra; that ability to do deductive reasoning in logic correlated .40 with the same ability in geometry; and that two successive levels of difficulty in ability to use fundamental ideas of space, number, and logic correlated .36.

from usage followed by inadequately trained adults or an earlier generation.

Meaning Arithmetic

Aims and Purposes. The case for the meaning theory of mathematical instruction was presented by Brownell (4), Wheat (40, 41), and others. Meaning arithmetic demands that arithmetic be intelligible, sensible, and useful to the learner rather than mechanical. The primary purpose of all mathematical instruction is to help children attain growth in the ability to think quantitatively. The ability to think thru a quantitative situation and arrive at sound conclusions with respect to it depends upon: (a) an understanding of the nature of the number system and especially of the principles and relationships which serve to make it an instrument for quantitative thinking; (b) a command of number symbolism—the language of mathematics; (c) a command of the fundamental processes; (d) the ability to correlate grouping arrangements described for specific social situations with the principles of mathematical grouping studied earlier.

Very little new research relating to the aims and purposes of meaning arithmetic was reported during the period 1945-1948. The research pattern needed to satisfy the exigencies of the meaning theory is vastly more complex than research based upon the drill theory. Brownell (3) has provided research workers with a survey of problems in need of investigation and has outlined needed changes in technical procedures to produce better studies of learning. Whiteaker (42) warned that no real assessment can be made of the values of meaningful instruction until the whole curriculum field is reorganized with a view to finding a topical continuity better designed to emphasize important number relationships. A number of curriculum problems were outlined.

Criticism of Meaning Theory. In the Second Report of the Commission on Post-War Plans (30) most of the program sponsored as meaning theory has been endorsed by the committee. On the other hand, Wilson (43) attacked the meaning approach as "disciplinarian," and "an attempt to stretch the mental powers of the child to the limit." Wheat (40, 41) criticized the tendency of some educators to take the middle-of-the-road stand with respect to meaning mathematics by setting up both social aims and mathematical aims.

Instructional Aims in Relation to the Growth and Development of Children

Three studies tracing the growth of number concepts in young children were reported. Mott (28) used the interview technic to show that of the forty-four children tested (age range thirty-four to seventy-three months) 92 percent had developed concepts for the numbers from one to ten. The are: (a) reduced drill load to be learned to 100 percent mastery; (b) abandonment of isolated textbook problems; (c) further progress in developing the recreational and appreciation approach in mathematics.

New Research. Several studies were offered in the period covered by this review which fit into this frame of reference. Russell (35) studied the use of decimals in the occupational world. He surveyed eighty-nine industries employing 68,000 persons. His report covers both the need for reading decimals and the limits of decimal computation.

Morton (27) studied children's interest in questions relating to aviation in Grades I-VIII as clues to grade placement of phases of this topic. He found that children were interested in the sociological aspects of aviation, especially in relation to speed, time, money, and measurement. He concluded that textbooks ought to be revised to supply more factual information and thus help children to gain number meanings thru experience. Lyda (25) studied the relationship between practical social experience and success in problem solving. He concluded that practical experience is a potent factor in success in solving problems—more potent for children below average in intelligence than for those of average intelligence or better.

Dexter (9) analyzed a recent arithmetic textbook series to compare the problem work with old texts and to see how well the needs of the social-utility program were being met. She found that 27 percent of the problems were purely artificial and that less than 1 percent of the problems were real to children.

Criticism of Social-Utility Theory. The theory underlying social arithmetic has been attacked by a number of writers. Wheat (41) has raised the following conceptual objections: (a) It does not follow that because the adult with his knowledge of number can see number meanings in specific social situations, the untrained child can experience the social situation and derive the number meanings as an outcome. (b) To split up and spread out the topics of arithmetic on the basis of frequency in adult usage is to ignore the principles of relationship and continuity within the topics. (c) A survey of the computational needs of adults is an inadequate basis for determining the mathematical content in the curriculum because the number responses of adults are so intimately intertwined with personal and social situations that he rarely dissociates one from another.

Other writers have joined in opposition. Brownell (3) criticized the social survey on the grounds that results obtained represented minimal standards for selecting content and was geared to a low level of competence. It would be better, he argued, to survey understandings and skills that are desirable. Johnson (20) criticized the research of Russell (35) on the basis that a survey of adult uses at a given time does not reveal processes that would have been used with better training. No improvement in methods or content can be looked for if the impetus must come

CHAPTER II

Aims and Purposes in the Teaching of Mathematics

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THE research related to the aims and purposes in the teaching of mathematics in both the elementary and the secondary schools is reviewed in this chapter. Part I deals with the research on objectives and aims in arithmetic in the elementary-school grades and in the mathematics commonly taught in the junior high school. Part II summarizes the research on objectives in high-school and college mathematics.*

I. Elementary-School and Junior-High-School Mathematics

The period 1945 to 1948 provided only a few published studies relating to the aims and purposes of teaching mathematics in the elementary and junior high schools. On the other hand, a number of articles of theoretical interest appeared which are certain to influence research in the immediate future. In view of this intimate relationship between actual research and its conceptual frame of reference, no apologies need be offered for the summaries of theoretical points of view here included.

Social Utility Arithmetic

Aims and purposes. The position of the advocates of social utility arithmetic has been summarized by Wilson (43, 44). According to this view arithmetic should equip the child for life by becoming a part of his life. This it does by providing "a valuable tool applicable to the affairs of daily living," and by providing a field of interest and enjoyment thru recreation. Mathematical phases of arithmetic content are often developed thru an appreciation approach. Frequency of appearance in social usage determines whether the classroom approach should be drill or appreciation. Skills, knowledge, and appreciations are to be emphasized in proportion to their usefulness in adult life. Schools are expected to provide direct experience in social situations (usually sizable thought-provoking situations) and from these the learner acquires both number concepts and social meanings.

Current Trends. Research to implement this approach has appeared at intervals since 1918. Much of the research consists of surveys of business, industrial, and personal needs for number concepts in the adult world. Other research reports the success of children in mastering the reduced drill load. Present trends in the social usage theory according to Wilson

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* Harold E. Moser of State Teachers College, Towson, Maryland, was mainly responsible for the material presented in Part I. Lucien Kinney of Stanford University, with the assistance of Charles Purdy of San Jose State Teachers College, prepared the material in Part II.

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The transition from high school to college can be made more efficiently by better articulating the two programs.

Much research is needed to improve instruction in science at all levels. It is gratifying to find that so many of the studies in science education during the past three years are of such high quality, but it is disconcerting to find that so much of this high quality research has not been published.

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grant credit for the physical-science course. His analysis of the replies should be useful in establishing respectability for such a course.

Using the rigid pre-professional training standards of the medical profession when investigating southern junior-college offerings in biology and chemistry, Chapman (15) found among other things that (a) for the most part, the junior colleges are making suitable offerings in both biology and chemistry, and (b) terminal and survey courses may be quite acceptable to general education, but should not be offered by the student to a medical college for transfer credit.

Investigating essential chemical backgrounds, Wiser (74) found that home-economics students need one year of inorganic chemistry, two quarters of general organic chemistry, and a third quarter of special organic chemistry devoted either to the chemistry of foods and physiological processes, or to the chemistry of textiles, depending upon the area of concentration.

Conclusions

Thruout the research summarized here there is evidence of a concern to use science to bring about a new and better culture, rather than merely to continue the past emphasis on implanting an old one. There is an increasing tendency to plan curriculum experiences that foster the proper emotional development of the child. The objectives expressed in the Report of the Science Committee of the National Society for the Study of Education in the Society's Forty-Sixth Yearbook, Part I, have been shown to be worthy ones for elementary-school children. Much of the subjectmatter formerly taught in the junior high school has now rightfully found a place in the elementary classrooms. The place of science in the junior high school is not clearly shown. In many instances it is merely a review of elementary work. Increasing emphasis is being placed on the scientific method as an aim at this level.

Tho the emphasis in the better schools at the senior-high-school level is upon the personal and social aspects of science, especially the use of the scientific method in solving problems and in making decisions, there are many reports of investigations that show but little concern for adolescent needs, interests, and problems, and in which there is little recognition of the connection between the school and the community.

The movement to provide an adequate orientation in science for all college students is gaining momentum, especially in teachers colleges and certain private ones. There is need for much improvement in this regard however, especially in the junior colleges, the Negro colleges, and the large universities.

The trend is away from highly specialized courses in the secondary school. Yet there seems to be a place for pre-vocational training based on job analyses in specific localities. The school is called upon increasingly to develop better citizens, fitted to earn a living or to pursue further studies.

of the donor shall appear, both because a proper credit is due him and because it will enable a reader to take into consideration any bias that may be included.

Preparation for Future Needs

On the basis of need as determined by job analyses of the chemical industries in the environs of Nashville and thruout the state, Holladay (30) developed a vocational-chemical education program for Nashville and projected programs for other centers thruout Tennessee.

Two studies were concerned with vocational agriculture. By an analysis of various reports and by personal visits to farm homes, Freeman (22) conducted an extensive study of the needs of Negro farm families located in southeast Missouri and then projected a program of education at Lincoln University for them and for other Negroes thruout the state. Using job analysis technics, Karls (35) constructed courses of study in agriculture for the elementary and secondary schools of southwest Missouri and for the Southwest State Teachers College at Springfield. He found great need for extending and improving agricultural education in the area studied. Only 40 percent of the teachers attending college had studied agriculture. In the construction of the courses of study, emphasis was placed on the poorest farm practice of southwest Missouri.

Preparation for Further Studies

The studies that have to do with preparation for advanced work are more concerned with easing the transition from high school to college, or with what background is favorable to success in a subject, than the propaedeutic objective itself. Investigating the effect of the study of high-school chemistry upon success in college chemistry at the University of Redlands, Hoff (29) found that the study of chemistry in high school had no significant beneficial effect on the grades achieved in college; also that a student has approximately a 50 percent chance of receiving the same grade in college chemistry that he received in high-school chemistry.

Garrett (24) reported on the method used to avoid repetition at Ohio State of work mastered in high school. From 5 to 15 percent of all beginning chemistry students who have had high-school chemistry pass proficiency tests which place them in second-quarter work and for which they receive five quarter hours credit. The distribution of the second-quarter grades reveals that most of the students receiving such credits surpass the remainder of the chemistry students.

Believing the physical-science course of the Summit High School of New Jersey to be more functional than the more traditional chemistry and physics courses taught there, Carleton (12) inquired of selected colleges and universities, including all of those to which Summit High School graduates go, to find if physical science is acceptable as a college entrance credit. Of the seventy-eight institutions that replied, all seventy-eight will preferences for particular units of health subjectmatter, and their interest in specific ailments. The interests revealed by the three methods correlated highly, with the exception that sex education ranked second as revealed in the personal interviews, but did not appear in either the questionnaires or in the oral reports. Also those personal interviews given to servicemen revealed an interest in marital relationships not evident among the high-school students.

In an effort to have the content and methods of instruction chosen because of their significance to human living, Manwell (47) developed health-teaching materials, and then determined the extent to which high-school teachers influenced the behavior of students by the use of these instructional materials. From the results of tests administered before and after the instructional interval the experimental group showed significant gains in information and slight gains in the other proposed areas. The investigator stated that the technic used in the development of the suggestions for teaching is suitable for application in other areas of instruction where there is a close relationship between problems of the individual or of social and modern scientific knowledge. Readers may wish to question the length of the instructional interval which was five weeks.

Lockwood's study (41) proved timely in that an outbreak of infantile paralysis occurred almost immediately afterward. The study was planned to help high-school pupils overcome fears of this disease arising from rumor and widespread misinformation. Pupil reaction and comments at the conclusion of the study and the reaction of parents showed that accurate information can help build a more wholesome attitude toward disease as well as increased respect for research studies related to health and disease.

Consumer Education

With regard to consumer education, Mallinson (46), by careful research procedures, selected and assigned seventy-three categories of consumer-education knowledges to principles and/or attitudes or general science courses. Thirteen of the knowledges were assigned to principles of physical science, forty-five to principles of biological science, and fifteen to scientific attitudes.

Describing the activities of the Consumer Education Study, Briggs (11) pointed out the need among educators for a wider concept of consumer education. Skill in judging commodities needs to be supplemented by an understanding of the general principles of our economy, of the machinery of production and distribution, and of wise procedures in planning for a full, rich life of cooperation with one's fellows. He also reported two criteria formulated by representatives of business and of education for judging the quality of commercially prepared materials offered to schools free or at nominal cost, namely, (a) all material offered by business to schools shall contribute directly to the enrichment of the educational program, and shall contain no sales promotion whatsoever, and (b) the name veloping a program framework in which curriculum offerings, pupil-teacher ratio, time-space facilities, and relationships with cooperating community agencies were considered. The investigator wisely avoided recommending specific subjectmatter and programs of activities, and suggested that syllabus revisions, to be developed by the various committees concerned, should be flexible and suggestive rather than prescriptive.

A unique and thoro study, which may be taken as a model for the development of health programs, was conducted by Tyler (67) serving as Health Education Consultant on loan from the U. S. Public Health Service. The objectives were to help the people of a given area develop a total health-education program which would give each individual an opportunity to participate, and to stimulate the development of health programs for larger areas. Careful surveys, previously made, provided the basis for planning, and each activity listed was carried out on a countywide, and in most cases, on a statewide basis. The investigator concluded that by working together a community can build up a health program which otherwise would be impossible; that the democratic method, altho slow, is sound and worthwhile; and that the methods and technics employed in this study are effective and would be useful in other areas. This splendid on-the-spot study must be read to be properly appreciated.

Maltby (48) studied the possible future importance and placement of nutrition education in Grades I thru XII of the public-school systems in the United States. Questionnaires were mailed to persons judged as experts in the field of nutrition. Upon the basis of 486 replies the following conclusions were drawn: (a) Human nutrition is sufficiently well established scientifically to justify its teaching in the public schools. (b) Nutrition education should be required for both boys and girls. (c) Current school-lunch programs do not provide sufficient nutrition education. The investigator found that public opinion is highly in favor of nutrition education as a separate subject in public schools, but that the chief obstacles are lack of recognition of need for such education, and lack of trained personnel.

Lockwood (41), working on the study under way at the Harvard School of Public Health, stated that the purpose of this research is to improve technics of nutrition education and to determine whether or not nutrition education, when incorporated into the curriculum, will aid in influencing and changing the food habits of children. To date the findings are at the elementary level, but data will be available later for the other levels. The schools receiving the most help showed statistical evidence of improvement in the children's daily eating habits. There was a favorable change of attitudes of children in relation to their food habits which persisted a year after the nutrition instruction. To get the best results, nutrition education should be carried on in a continuous and progressive manner.

By means of 1100 questionnaires, 450 personal interviews and an analysis of 500 voluntary class reports, Haar (26) determined the learners' course toward present and future needs, an analysis was made of science materials in representative periodicals and student selections of activities. Eight subjectmatter areas were selected—animals and plants, food, body form and function, man's activities, man's uses of materials, and science and man's thinking. Student problems, classifiable as personal and behavior problems, family problems, community and social problems, and intellectual and esthetic problems were used in determining what to teach in the eight areas. Out of this a program of instruction, consisting of projects and group experiences, chosen on the basis of individual interests and needs, was developed. Not only does the course contain all the facts and principles ordinarily found in a standard biology course, but also much additional material.

Primarily by analysis and jury technics, Bergman (7) procured and matched with biological principles a list of fifty principles of entomology. By similar technics he determined the significance of these principles to twenty-five criteria of general education. In this study the principles were listed in serial order according to their significance for general education.

Friedenberg (23) compared the development of an experimental group of freshmen agriculture students taking chemistry from a needs approach with that of other freshmen studying chemistry from the traditional subject-matter approach. He found the experimental group demonstrably superior in their ability to apply chemistry to all but one of the needs areas considered in the course, and there was no evidence of inferiority in regard to that single area. There was evidence of the experimental group's inferiority, however, on a published examination measuring the traditional objectives of chemistry, and on the control group's own examinations. It seems pretty clear that the objectives one strives to attain have much to do with the outcomes of instruction.

Health and Nutrition Education

General concern is expressed among research workers over the status of health education in the schools of the nation. This concern is perhaps an outgrowth of the war, which revealed startlingly poor conditions among young men being examined for military service. Researchers in recent years have attacked the problem from various viewpoints: administrative, basic philosophy, pupils' ideas of the importance of content, and attitudes toward health.

Part I of the Forty-Sixth Yearbook of the National Society for the Study of Education (54) revealed the trends in health education. The committee preparing this book recommended that health education be integrated with the entire school curriculum with one exception, that in the eighth year a one-semester separate course in health and physiology be presented. The findings of the following studies are in general in harmony with the committee's recommendations. Carmody's study (14) attacked the health-education problem from the standpoint of the administrator in de-the student in seeing the relationship between learning and life and in using his skills in daily living, and (d) an attempt to reform graduate education for teachers. He advocated that our ideal of an educated man should be one educated for the life, labors, problems, and pleasures of our time.

In a report for the research committee on junior college science, Van Deventer (69) classified the general education science courses as of three types, survey courses, problems courses, and cultural heritage or historical courses. Of these types the survey course is by far the most widely known and best established. Interest in integrated science courses is on the increase in all types of institutions; most progress has been made in teachers colleges and least progress in junior colleges and Negro colleges.

Dodds and Lefler (18) reviewed the articles and researches that treat the influences of science and technology upon education in college. Rush (61) described a systematic process that he used in setting up objectives for a general course and then outlined means of implementing these objectives.

In an exhaustive study, Jordan (34) dealt with the problem of how, in a university, a student majoring in a field other than science is to secure a liberal education in science, and as a corollary, how the science major can acquire a grasp of concepts embodied in branches other than his own. He examined the aim of liberal education together with its relationship to democratic living, the general and specific shortcomings of Liberal Arts science programs for general education, laboratory study, and certain specific aspects of the curriculum. He concluded that use, or the needs of the student, should be the principal criterion to use in choosing material for science courses in general education. He suggested the development of comprehensive, rather than survey courses, according to these principles: (a) The course should be built around a nucleus of basic principles of various phases of science with principal facts that are needed to build these principles. (b) The content should be completed with a discussion of common phenomena. (c) The content should be arranged in a sequence to illustrate the manner in which concepts have developed historically. (This does not pertain to choice of content, but merely to arrangement; the student's present environment is the controlling factor in choice of content.) (d) Reference should be made to the interaction between scientific development and social change. Using the above principles Jordan built a curriculum for a one-year course in physical science.

On the basis of the opinion of fifty students who had completed survey courses, Blanchet (9) attempted to determine the relative desirability of different topics for inclusion in survey courses in biology and physical science. However, the lack of agreement was so great that he concluded such opinions are of little value in selecting course content.

Van Deventer (68) described the studies and procedures used in developing the general biology course at Stephens College. To orient the

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CHAPTER III

Methods and Materials in the Teaching of Science*

JOHN S. RICHARDSON and J. DARRELL BARNARD

THERE is an increasing amount of evidence indicating that the program in the teaching of science is a cooperative activity in which the teacher and students work together in determining objectives and methods, in pursuing investigations, and in drawing conclusions and evaluating outcomes.

Current Practices in Science Teaching

According to the 1947 Yearbook of the National Society for the Study of Education Part I (22), progress toward greater cooperative activity in the classroom has been particularly evident in junior-high-school science and in biology. These teaching practices have not been used so effectively in high-school chemistry and physics. Teaching practices in general have not been successful in developing ability to use the scientific method as an outcome of science education. A more encouraging report was made by Leonard (16) who studied the practices used in the high schools of thirteen school systems and found evidence of schools utilizing direct approaches to learning in science, with well-equipped laboratories operating in functional ways. He also found schools making use of effective methods of research and investigation, with specific attention to competence in expression and the communication of ideas.

The use of direct experience in the elementary school was the thesis of the bulletin, *Science Education for the Elementary Schools of Ohio* (27). According to this bulletin direct experiences may be used in promoting effective learning thru cooperative group activity. The status of science in the elementary school was one concern of the committee reporting to the President in the publication entitled *Manpower for Research* (28). In this report the President's Research Board utilized the report of the Cooperative Committee on the Teaching of Science and Mathematics which had been authorized by the American Association for the Advancement of Science. Altho the committee recognized the deficiencies commonly present in the teaching of science in the elementary schools, the committee found encouraging developments in the preparation of curriculum materials and teaching aids. Some specific indications of the encouraging trend in elementary-science teaching are as follows: (a) the increased allotment of time to science; (b) an increase in the number of science classrooms equipped with laboratory equipment for providing science experiences; (c) the provision of more and better visual materials and supplementary reference materials; (d) the increase in the number of well-written textbooks; and (e) curriculum provisions for problem-solving activities.

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* The first five sections of this chapter were originally written by John S. Richardson.

Several studies have been conducted which are indicative of the emphasis that is currently being placed upon the desirability of cooperatively developed learning activities in science based upon the needs and interests of the learner. Bissari (5) conducted a study to determine the status of junior-high-school science and to determine the means by which it could be improved. The sources of the investigator's basic data included previous investigations, opinions of authoritative writers, courses of study, interviews with school principals and questionnaires submitted by science teachers. One hundred and sixteen schools in forty-five states were represented in the study. Based upon the findings of this study a number of generalizations were developed to serve as guides in the improvement of junior-high-school science instruction. Certain of the generalizations stated that science teaching should be organized around large units of experience based upon the pupils' needs and interests.

An investigation in a high-school physics class conducted by Hellman (13) included the planning of laboratory studies of the pupil's own choice. Hellman reported that results in pupil understanding and learning by this procedure were superior to those achieved by the traditional methods. A somewhat similar study was made by Lockwood (18), who designed a project to combat needless fear and panic among children and parents caused by the occurrence of poliomyelitis in a community. The study included approximately one hundred students of the tenth-grade biology classes in a Detroit school. The students participated in planning a study which included an investigation of fears, and popular questions regarding the disease. Numerous sources of information which had bearing on these and other phases of the general problem were utilized. It was reported that the project resulted in: (a) the replacement of fear by wholesome attitudes, (b) the replacement of hearsay by fact, (c) acquisition of information concerning symptoms of the disease, and (d) an increased appreciation of the need for research in all studies of health and disease.

Selection of Learning Materials

With the growth of science as a part of the elementary-school curriculum, the selection of learning materials appropriate to the objectives and methods has become increasingly important. A major criterion for the choice of materials, as set forth in the Forty-Sixth Yearbook of the National Society for the Study of Education Part I (22) is that the materials should come largely from the child's environment. The same point of view is expressed in the bulletin, *Science Education for the Elementary Schools of Ohio* (23). These documents emphasized the use of materials that are familiar to the pupil, the advantages of using materials that can be obtained thru local sources, and the construction of simple equipment as a desirable form of learning. It was also pointed out that the supply of motion pictures, slide films, and other visual and auditory materials is inadequate at the elementary-school level.

Audio-Visual Aids

An extensive survey conducted under the sponsorship of seven publishing companies (7), revealed among other things, a number of pertinent facts regarding the use of teaching films in 424 of the 501 largest public-school systems in the country. For this part of the study information was obtained thru questionnaires introduced and distributed to school personnel by salesmen of the sponsoring publishers, and thru interviews with visual-education directors conducted by a staff of well-trained research workers. In both the elementary and secondary schools, films were found to be used most frequently in science and social-studies classes. It was evident that the teachers included in this study were having difficulty in making effective use of teaching films. These teachers reported a variety of criticisms regarding the films which they had found unsatisfactory. These included criticisms pertaining to the appropriateness of the film, its subjectmatter and content, quality of the script, quality of production, obsolescence, and advertising. Science teachers were found to make unfavorable comments more often than the other high-school teachers. Subjectmatter and content of films were most frequently the subjects of their criticism.

Miles and Spain (20) reviewed the use of audio-visual aids in the armed services. On the basis of a considerable quantity of cited research and studies of opinions, the following conclusions were formulated regarding the educational value of audio-visual aids: (a) Films can and do affect emotional attitudes in predetermined desirable directions, and they increase factual knowledge and promote the length of its retention. Filmstrips are valuable, but are not so successfully used as motion-picture films. (b) The preparation of the student for seeing a film increases the learning value of films, and audience participation in the use of filmstrips increases the amount of factual knowledge gained. This increase was especially significant with difficult material, with groups of low motivation, and with groups of average and low intelligence. (c) The research studies on the effectiveness of special audio-visual devices permits no general conclusions. (d) All studies of the opinions of the instructors and trainees indicate a general approval of the extensive use of audio-visual teaching aids.

Keeslar (14) attempted to determine the extent to which selected instructional films in science contributed, particularly by means of the unique and special functions of the medium, to the realization of three major objectives of secondary-school science. The three objectives with which this study was concerned were: (a) to effect an understanding of everyday scientific principles, (b) to teach the elements of scientific method, and (c) to develop the scientific attitude. In carrying out this study twenty-four films rated as "excellent" in two outstanding film catalogs were selected. These films were analyzed on the basis of evaluative criteria. The evaluative criteria were designed to determine if the films served unique functions of films in teaching, if they served specialized functions, or if they contributed to the three major objectives of science teaching. A special check-sheet was devised and a record was kept as to whether or not each individual scene in each film contributed to the above objectives. The reliability of the investigator's judgment was checked by a second analysis of three of the films six weeks after the first analysis, and agreement in 90 percent of the cases was found. The validity of the investigator's judgment was checked by having most of the three films analyzed by three experienced science teachers with an agreement of 86 percent, while a check of the investigator's second analysis with that of the three judges showed a 95 percent agreement.

On the basis of the evidence found in this sampling of the best films for use in high-school science classes it was shown that unique functions of films were served by 48 percent of the films, that specialized functions of films were served by 8 percent of the scenes and that only 5 percent of the scenes were found to contribute to any of the three selected objectives of science teaching. Therefore, nearly half or 44 percent of the twenty-four films served no unique or specialized function and contributed to none of the three so-called major objectives.

Commercial Materials, Devices, Pictures, and Books

The abundance of supplementary learning materials which are available to science teachers from commercial sources has made the problem of selection a difficult one. In an effort to help science teachers, a committee of the National Science Teachers Association, in cooperation with the Consumer Education Study of the National Association of Secondary-School Principals (21) undertook an investigation of the problem. As a result of this investigation certain uses which could be made of commercial materials and factors limiting their uses were identified. Commercial materials were found to be useful in: (a) supplementing the information available in textbooks, (b) providing accurate sensory experience, (c) maintaining a stimulating atmosphere in the science classroom, (d) providing experience in the application of scientific principles, (e) providing current materials on new developments in science, (f) aiding in the analysis of objects and processes, (g) stimulating student interest in science, (h) developing the special interests of individual students. Factors which limited the use of commercial materials were: (a) the presence of an objectionable amount of advertising or sales promotion material; (b) the variety of sizes and shapes made the material difficult to store, catalog, exhibit, or use; (c) content which was not appropriate or which was not presented in a way conducive to learning; (d) the presentation of information which was inaccurate, half-true, or distorted; and (e) nonavailability of material when requested. It was proposed that commercial materials should be used only when it was certain that they made a positive contribution to the educational program and contained no objectionable advertising.

Stollberg (29) investigated the possibilities of providing and using teaching devices in the study of electronics. He designed and produced vertically placed panels upon which plaques bearing pieces of electronic equipment and schematic diagrams of these pieces of equipment could be placed and studied while in use. The design of the equipment for demonstration use and for individual laboratory study, along with the explanations of its functions and uses, and suggestions for teaching constitute a significant contribution to this developing aspect of science in life activities.

Goins (11) analyzed ninety-seven pictures from *Life* and *Fortune* to determine their appropriateness for use in science classes. Most of the pictures were found to be valuable teaching aids in two or more science courses.

As the result of a review of 145 high-school chemistry texts published between 1802 and 1944, Rice (25) found that the number of illustrations in chemistry texts had increased and that more applied science was included in current chemistry texts.

Storage of Materials

Provision for adequate storage of learning materials is a problem that apparently has been given little attention by the investigators. The importance of this problem was recognized in the report prepared by the National Science Teachers Association for the Consumer Education Study of the National Association of Secondary-School Principals (21). A method of solving one aspect of the problem was developed by Richardson (26), thru a study of the functional storage of pamphlets and charts. Greene (12) investigated the storage of laboratory equipment and supplies. On the basis of recommendations and requirements of state departments of education, the recommendations of textbooks and laboratory manuals, of equipment lists of manufacturers of science apparatus for high-school use, and of questionnaires sent to teachers of high-school chemistry, Greene developed master lists of equipment and supplies for chemistry, physics, biology, and general science. The requisite storage area was calculated from these lists. Recommendations for drawer, shelf, and cupboard space were made. Formulas for the use of these recommendations by schools having single laboratories for chemistry and physics, for general science and biology, and for schools having a single general laboratory, were developed.

Effective Ways of Using Learning Materials

An eighteen-month study of the use of current materials in classes was made in eleven cities and towns in California under the direction of the California State Department of Education (6). Sixteen schools and thirty-six teachers participated in the study. Of the seventy-two classes, twenty-two were in science. Materials used included current magazines of pictorial-news types, current educational films and recordings, pamphlets produced by industrial and commercial organizations, and many films and filmstrips. The study began with a workshop for teachers to clarify purposes, study procedures, and methods of evaluation. Representatives of the State Department of Education and Stanford University made regular visitations to the schools included in the study. Conferences for teachers were conducted on several occasions during the period of the study. Emphasis upon the use of current materials in the classroom was brought about thru a variety of procedures including panel discussions, individual reports, field trips, use of bulletin board, displays, and recordings. The achievement of classes in which current materials were used was compared to the achievement of control classes conducted according to standard practices. Students using current materials made as good scores on tests covering the standard curriculum as did students in the control classes. The greater resourcefulness required to use current materials resulted in better interest and participation and more critical thinking. The varied approaches provided for individual differences among students. Students developed respect for each other and a sense of individual responsibility. Attitudes favorable to and habits in the use of current materials were developed. Teachers were reported to have benefited from the study by developing skills in locating and using current materials and by learning to plan with the students. Better relationships with the home and community were believed to have been achieved thru the study.

Lockwood (19) reported a study designed to determine whether nutrition education in the elementary school would aid in changing the food habits of children. Six elementary schools in Newton, Massachusetts participated in the study during the school year 1946-47. The intelligence of pupils in the different schools was as comparable as is possible in dealing with entire school populations. Two of the six schools were used as controls, and the teachers in these schools were not encouraged to emphasize nutrition education any more than they had been accustomed to doing. In two other schools the teachers were supplied with pamphlets, posters, charts, films, and other teaching aids pertaining to nutrition at the elementary level. Teachers in the remaining two schools were given teaching-aid kits plus workshops, demonstrations, and personal conferences. These materials and teacher activities were planned to give teacher assistance in incorporating nutrition education in the different activities of the elementary school. Before the study began and at two different times during the year, dietary surveys were taken of each of the 3300 children included in the study. Comparisons of the relative effectiveness of the different approaches to nutrition education were based upon the findings of these surveys.

In the two schools where teachers were given assistance thru workshops, demonstrations, personal conferences, and visual aids, children were reported as showing statistical evidence of improvement in their daily eating habits. There was also evidence to indicate that the attitudes of children toward new foods improved during periods of definite and continued emphasis upon nutrition education. There was a rapid decline in interest in daily food adequacies of the basic food needs during periods when nutrition education was not emphasized.

Methods of Using Motion Pictures

Wise, Miller, and Wahl (36) reported a series of two studies designed, among other things, to determine the relative effectiveness of various methods of using selected sound motion pictures in general science classes upon subjectmatter learned. In the first study, a film entitled "Electrodynamics" was shown to 180 pupils enrolled in eight general science classes after the completion of the unit on electricity and magnetism. In four of the classes the film was introduced with a carefully planned discussion and followed by a discussion of its content. These discussions were presented by the investigator. In the other four classes the film was shown without preliminary or summary discussions. Objective type tests, covering the subjectmatter included in the film, were administered before the film was shown, one week after, and again seven weeks after the showing of the film. Classes in which planned discussions were used to introduce and follow up the showing of the film made significantly greater gains in both immediate and delayed recall of subjectmatter than classes in which no discussion was used.

In the second study an attempt was made to determine whether gains similar to those obtained in the first study might be expected for different sound films and whether similar gains might be made by having the regular classroom teachers prepare and present the discussions used with the films. Two eighth-grade classes in general science were shown two sound films, "Heat and Fuels" and "Weather" approximately one week after related units were studied by the classes. The first film was shown to one eighth-grade class after a thirty-minute discussion period directed by their regular teacher and based upon a learning guide developed for the particular film. The same film was shown to the other eighth-grade class with no preliminary discussion. The method of presenting the second film to each of the eighth-grade classes was reversed so that each class saw one of the films by each of the methods of presentation. Two ninth-grade general science classes were shown two sound films, "Water Power" and "Simple Machines" following a procedure similar to that used with the eighth-grade classes. An objective-type test was used for measuring the recall of subjectmatter covered in each of the four films. The test for each film was given before the film was shown, one week after, and again seven weeks after the showing of the film. Groups were equated for purposes of comparing results obtained by each of the two methods. With the exception of gains on the test on "Water Power," the gains made by pupils observing the films after preliminary discussions were significantly greater than the gains made by pupils observing the films without discussions.

An investigation of the effectiveness of note-taking while viewing motion pictures in high-school science classes was made by Ford (10). Thirty students of ninth-grade science were shown three sound films by each of three procedures. With the first film there was neither preparation nor preconditioning. With the second film the students were told to take notes during the showing for reference later in preparation for a test. With the third the students were given reading references two days before. Prior to showing the film appropriate models were demonstrated and discussed. This was followed by listing the things which they should look for in the film. The students were directed not to take notes and were told that a test would be given immediately after the showing. On the basis of the tests given in each case the investigator concluded that note-taking during the showing of a film distracted from the learning principles whereas adequate preparation of the student for observing a film encouraged greater learning and promoted good conduct.

Nature of Learnings in Science

An understanding of the nature of specific learnings, their relationship to each other and factors affecting their achievement is essential in planning and administering effective learning activities in science.

In a study involving 600 boys and girls, Alpern (2) found that high-school pupils possessed ability to test scientific hypotheses as measured by evaluative instruments by the investigator. Low correlations were found between intelligence, chronological age, and previous science taken by pupils and their ability to test hypotheses. No statistically significant differences were found between the ability of the pupils in testing hypotheses.

Wise (35) conducted a study to determine the relationship between the abilities involved in recalling information, solving conventional problems in physics, and applying principles of physics to problems encountered in out-of-school experiences. Objective-type tests designed to measure these abilities were administered to physics classes in seven high schools at the completion of each of the four conventional units in physics. It was found that the abilities to recall information and solve conventional problems in physics were not identical to the abilities involved in applying principles of physics in solving problems encountered in out-of-school experiences.

As the result of a study involving twelve classes in high-school biology, Weisman (34) found that the teaching method used, general intelligence of the pupil, reading ability, the amount of mathematics the pupil had previously taken, partiality for science, and skill in critical thinking, had a relationship to the pupil's ability to interpret data in biological science. Within the age range of pupils included in the study, the ability involved in the interpretation of data was not found related to sex or age. The extent to which method of teaching was found to be a factor in developing the ability to interpret data is reviewed in a later portion of this chapter.

Special Course Organization and Teaching Technics

A number of investigators have been concerned about the effectiveness of various kinds of course and unit organizations upon the achievement of certain outcomes in science. Others have attempted to develop teaching technics which would be effective in achieving specific outcomes.

Subarsky (30) compared the relative effectiveness of an experimental procedure and the conventional procedure for administering high-school biology and social-studies classes upon the achievement of biologically and historically valid concepts and desirable attitudes regarding discriminatory social practices. By the conventional procedure pupils were taught biology and social studies in separate classes. By the experimental procedure the biology and social-studies classes were brought together at two different times for a two-week period given over to integrating what the pupils had been studying concerning the physical and cultural aspects of human development and group relations. As measured by the tests used in this study there was a significant positive change in the attitudes of pupils studying by the experimental procedure. There was no significant change in the attitudes of pupils studying by the conventional procedure. The findings of this study suggest one way in which more effective learning might be achieved in an area of human relations important in democratic living. This study also indicates a way in which resourceful and energetic science and social-studies teachers could plan more functional educational experiences even within the course pattern and organization found in the conventional high school.

Reports of several studies present some evidence regarding more effective organizations of learning activities and more effective teaching technics, altho they were not based upon the findings of controlled experimentation. Adams (1) devised laboratory demonstrations which would be useful in developing an understanding of the thirty generalizations of physical science which were found to be most functional in the activities carried on in industrial arts shops. Kotlar (15) described a course for twelfth-grade pupils on the interaction of science and society and reported that the results of tests indicated that pupils were apparently getting the important generalizations of the course. Lewis (17) described a procedure which was found effective in preparing laboratory exercises in junior-college science designed to develop abilities in using the scientific method. Robinson (27) attempted to develop a fused science course for Grades XI and XII which would help the individual become a more effective participant in a democracy.

The nature of these reports might be interpreted to mean that science educators are becoming increasingly concerned with the development of course organizations and teaching technics which will help persons taking science achieve outcomes of greater personal and social significance.

Bases for Comparing Methods

A number of investigators have attempted to compare the relative effectiveness of different methods of teaching science. Various learning outcomes were used as bases for determining the relative effectiveness of the methods investigated in the studies reviewed here. It is interesting to note the importance that has been placed upon attitudes, abilities in problem-solving and the application of the subjectmatter of science to practical situations. Altho outcomes related to scientific attitudes and abilities in problem-solving are defensible bases for comparing the effectiveness of different methods of teaching science, there is still a great need for valid and reliable instruments to measure many of the elements involved in these outcomes.

Enrichment and Problem-Solving Methods

Baar (3) conducted a critical analysis of selected literature dealing with methods of teaching science and synthesized three enrichment methods. An enrichment method was considered to be a teaching procedure which seemed to modify the quality of pupils' school life in a meaningful way. One method, an activity method, involved the use of differentiated enrichment activities. The second, a problem method, made use of the scientific method. The third, a social implications method, emphasized the social implication of science.

In the second part of this study an attempt was made to compare the relative effectiveness of each of the three methods and combinations of the three methods in teaching general science based upon growth in the ability to determine cause and effect relationships; understanding the social implications of science; comprehension and interpretation of scientific problems, experiments and achievements; and application of principles and reasoning in the application of principles. The achievement of groups of general science pupils in six classes taught by the experimental methods was compared to the achievement of general science pupils in an equated group taught by a conventional method involving textbook, recitation, and lecture demonstration. Achievement was measured by objective tests administered before and at the end of the period of instruction. In general, the enrichment methods were found to realize better achievement in the outcomes with which this study was concerned, altho the differences in favor of the enrichment methods were not statistically significant in all cases.

Bloom (4) investigated the effects of instruction in problem-solving upon the improvement of abilities in problem-solving and upon general achievement of a selected group of college students. Interview tests were given selected students to determine the procedures they used in arriving at conclusions to specific problems included in examinations covering the fields of social science, humanities, and biological science. Difficulties encountered by students of various achievement levels were compared. The poorer students had difficulty in understanding the problem, had less confidence in their ability to solve problems, and tended to drift aimlessly thru the problem. Students in general were found to possess the essential information needed to solve the problems. Remedial work in problem-solving, where the technics used by better students were studied, realized greater improvement in the problem-solving abilities of students when compared to equated groups of students who had not been given the remedial work. Students who had been given remedial work in problem-solving also made better grades on examinations covering general learning outcomes than students in the control groups. The reliabilities of the differences obtained were not reported.

Laboratory Methods

Cunningham (8) analyzed thirty-seven studies dealing with the problem of lecture demonstration *versus* individual laboratory methods in teaching science. These studies included six doctoral theses, eighteen master's theses, and thirteen articles. It was found that the data did not conclusively favor one method over the other. The desirability of one method over the other was determined by the objectives sought and the conditions under which the course was taught.

Tobler (31) found that high-school biology pupils, who were required to label prepared drawings, made better scores on examinations selected to measure factual learning and functional values of the products of learning than equated groups of pupils who were required to prepare and label all drawings.

Weisbruch (33) found a "semimicro" method of conducting laboratory work in high-school chemistry to be superior to the "macro" method based upon achievement in laboratory procedures and knowledge of the subject-matter of chemistry.

Effects of Method upon Ability to Interpret Data

Weisman (34) compared the relative effectiveness of two methods of teaching high-school biology upon achievement in the ability to interpret data in biological science. Six experimental classes and six control classes in tenth-grade biology from the same high school participated in this study for a period of nine months. The experimental classes were taught by a method which provided for teacher-pupil cooperation in selecting the problems and planning the activities for the biology course. Emphasis in the experimental classes was placed upon solving problems selected by pupils. The control classes were taught by equally good teachers using their customary methods within the conventional organization of the biology course. Mental ability, ability to do critical thinking, knowledge of biology, reading ability, and ability to interpret data, as measured by tests administered before the period of instruction, were used as bases for equating the groups.

It was found that pupils in the experimental groups achieved reliably greater gains in the ability to interpret data as measured by the *Interpretation of Data Test*, than did pupils in the control groups. Pupils in the experimental groups also made significantly greater gains in learning facts and principles of biology as measured by the *Cooperative Biology Test*. One year after the period of instruction pupils in the experimental groups had retained their superiority over pupils in the control groups in the ability to interpret data and in knowledge of biological facts and principles.

The findings of this study correspond to the findings of related studies which have previously been conducted in that it was found possible to achieve certain of the abilities involved in problem-solving as outcomes of science instruction. Furthermore, technics of teaching involving the cooperative participation of pupils were found to be more effective than teacher-dominated methods in achieving these outcomes.

Student Opinions in Evaluating Methods of Teaching

The opinions of students have been used in some studies as one means of evaluating teaching procedures at high-school and college levels. Two such studies will be reviewed here. By using a questionnaire, Doll (9) obtained the preferences of 1237 pupils in six New Jersey and Pennsylvania high schools for teaching procedures which he classified as *laissez-faire*, low-level democratic, high-level democratic, and totalitarian. Respondents to the questionnaire identified many weaknesses in traditional teaching methods. They desired guidance in learning but not domination by the teacher.

Park (24) obtained opinions from fifty-four high-school pupils and ninety-three college students regarding the effectiveness of motivating technics which had been used by their teachers. He found that competition, rewards, and prizes were frequently used by teachers and were judged to be successful motivating technics by about one-third of the students. Audio-visual aids were mentioned by 18 percent of those responding whereas 19 percent of the group considered the teacher's personality and knowledge of subject to be important factors in motivating learning. No attempt was made to distinguish between the motivating technics used by teachers of various courses.

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CHAPTER IV

Methods and Materials in the Teaching of Mathematics

HERBERT F. SPITZER and ROBERT L. BURCH

THE summaries of research relating to methods and materials in the teaching of mathematics are presented in two sections in this chapter. Part I deals primarily with the problems of teaching arithmetic in Grades I to VI. Part II is concerned with the methods and materials related to the teaching of mathematics in the secondary-school and college levels.*

I. Mathematics in Grades I thru VI

Since the preceding report in this series (11), a large proportion of the writing on methods and materials has been concerned with general methods, the grade placement of topics, and the nature and place of meaning in teaching arithmetic. Once more it is true that only a few of the articles and studies reviewed here consist of reports of controlled research on the problems of teaching arithmetic.

The nature and place of meaning in the teaching of arithmetic was dealt with by Brownell (6, 7, 8, 10). He distinguished between meaning *of* and meaning *for* in the case of arithmetic and suggested four categories under which the meanings of arithmetic might be grouped (6). Pointing out a general confusion resulting in the teaching of social applications of arithmetic rather than the meanings and rational principles which make arithmetic a phase of mathematics, Brownell listed objections to teaching meanings, followed by reasons for teaching them (10). He explained and illustrated his concept of meaning (7, 10), and listed results of experimental situations which favored his meaningful method of teaching borrowing to third-grade pupils, over mechanical methods taught to another like group (10). Implications for research in arithmetic were outlined (8) as problems under two headings: (a) making arithmetic sensible, and (b) making arithmetic useful. Technical procedures needing change are those involving control, measurement of progress, length of observation, and the base of evaluation. A word of caution concerning superficial meaning was offered in an article by Whitney (71).

Stevens (63) in reviewing trends in teaching listed five procedures of note: (a) There has been a marked increase in the time and attention given to concept-building programs. (b) Abstract work has been delayed. (c) Methods of today recognize and accept immature ways of dealing with number situations. (d) There has been a decided increase in, or a return to, oral work. (e) The emphasis today is on individual in place of mass instruction.

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* Herbert F. Spitzer of the State University of Iowa is responsible for the preparation of the material presented in Part I and for the references dealing with the teaching of arithmetic. Part II was prepared by Robert L. Burch of Boston University.

Six principles embodying a usable philosophy are listed by Cooke (11): (a) Introduce concepts and problems of arithmetic only when the child is psychologically prepared for them. (b) Practice and drill on those topics that need practice and drill. (c) Recognize and provide for individual differences among pupils thru diagnostic and remedial procedures. (d) Approach problem-solving logically. (e) Use word problems with a vocabulary one grade below the arithmetical level. (f) Socialize and configure word-problem material.

In a critical analysis of the backgrounds of arithmetic, Renfrow (55) pointed out the impossibility of substituting algebra for arithmetic, the importance of the concrete approach in arithmetic, the need for mastery rather than omission of number processes, and the necessity for drill.

Gavian (23) listed and analyzed a number of problems that might be used to develop socio-economic understanding. As a part of the analysis, questions that six- to seven-year-old, eight- to ten-year-old, and ten- to twelve-year-old children might ask were listed. An example is, "How may boys and girls add to the income of the family by other means than earning money?" Larrick (41) observed that more children are handling a larger share of the family income. Children in families where both parents work are doing the grocery shopping and need lessons in money management.

Fawcett and Barcus (21) presented a report in which conservation situations are used as the basis for mathematical study exercises. The procedure offers what appears to be an excellent way to study some problems of conservation and if generally adopted should result in good uses of mathematics.

Orienting his thinking along the line of use and efficiency, Hill (31) urged a high degree of uniformity in (a) understanding of the objectives and philosophy functional to the teaching of arithmetic, (b) philosophy of textbooks used, and (c) procedures taught to children. He concluded that the place for teachers to show initiative is in the formulation and use of devices which make the work understandable to children. Essentially the same plea was made by Steel (62).

In an article, "The Social Utility Theory as Applied to Arithmetic," Wilson (74) reviewed the long struggle between the followers of mental discipline and the followers of use. The most significant studies on use of numbers were cited or quoted, and the type of program previously proposed by Wilson was recommended. Two separate studies, one by Mott (51) and one by Stotlar (64), on the number abilities of four- and five-year-old children were reported. In general the findings of these two studies were similar to earlier and more extensive studies in this area. In both studies the conclusion was reached that four- and five-year-old children do use and have need for numbers, and therefore might profit from instruction. Because some children counted a larger number of blocks than the highest number reached on the rote counting test, Mott reached the somewhat dubious conclusion that rote counting plays no part in learning to enumerate objects. Altho no evidence in support of the statement was submitted, Mott stated that rote counting was a handicap.

Mott and Martin (50) reported that with the exception of counting by rote to 100, children carry over into the first grade after a lapse of three months the number experiences they have learned in kindergarten. The results of the test showed this general tendency in every ability except rote counting to 100, a fact which raises the question as to whether the number concepts tested were learned in school or out of school.

In a comprehensive summary of a series of studies Osburn (52) presented an analysis of difficulties in long division. For one type of division, that of a two-digit divisor and a one-digit quotient, the number of possible examples for each of forty-one levels of difficulty was presented. The 49,050 possible cases for this one type of division were classified according to whether or not the apparent and the increase-by-one method of finding the quotient can be used successfully. (The figures Osburn quoted vary slightly from those reported in an earlier study by Grossnickle. For example, the latter reported that in 63 percent of all cases the apparent method succeeded, while Osburn reported 61 percent.) Osburn recommended that only the apparent method be taught to beginners.

In another report on the relative accuracy of estimates of the quotient when the increase-by-one and the apparent methods were used with two-figure divisors, Morton (48) recommended the increase-by-one method for two place divisors ending in 6, 7, 8, 9. His data showed that by following this rule estimates will be correct in 79 percent of the cases, while with the apparent method correct estimates will be obtained in only 36 percent of the cases for divisors ending in 6, 7, 8, and 9. Morton states that this use of the increase-by-one rule with divisors ending in 6, 7, 8, and 9 combined with the use of the apparent method with divisors ending in 1, 2, 3, 4, and 5 is in harmony with the practice of rounding numbers in other situations. The fact should be noted, however, that in general practice a number ending in 5 is more frequently increased in rounding than decreased, as Morton suggests.

Karstens (37) described a study which showed that it is possible, by using only the first two figures of any multifigured divisor, to select the correct quotient in almost 100 percent of the cases without doing any writing. This method consists of rounding off the divisor to the first figure and obtaining an approximate divisor. The estimated quotient should then be checked by multiplying the first two figures of the divisor by the estimated quotient before writing the product. If the check product can be subtracted from the first three figures of the dividend, it is safe to assume a high degree of accuracy for the estimated quotient.

After analyzing the ability to recognize relationships in problems, Spangler (60) suggested the use of oral problems and listed fourteen procedures for improving pupils' ability to read problems. She reported further that improvement in problem-solving on the *Stanford Achievement Test* accompanied improvement in reading.

Also implying that teachers should provide practice at verbal levels is Hall (27), who gave a test consisting of fifty one-, two-, and three-step problems covering addition, subtraction, multiplication, and division of whole numbers to 179 unselected sixth-grade pupils. He found considerable individual differences but no significant differences between the ability of boys and girls. The order of difficulty of steps was as follows: addition (53 percent correct), subtraction (52 percent correct), division (49 percent correct), multiplication (42 percent correct). The order of difficulty of steps was as follows: one-step (66 percent correct), two-step (47 percent correct), three-step (32 percent correct).

Maintaining that reliance upon a formal system robs pupils of self confidence in whatever problem-solving ability they had, and in effect makes them slaves to the system, Beatly (1) withholds approval of all systems, (such as "step analysis") for problem-solving. He prefers that the teacher shall "supply a sufficient number of genuine problems which the pupil has a good chance of solving successfully by his own thinking" together with enough problems that stretch the pupil's power in order to whet interest. Payne (53), in an article entitled "Arithmetic Troubles," used the findings of research studies in a way that should be of vital concern to all research workers. She pointed out that research has shown that over one-half of the children in fifth grade are not ready for the study of fractions, and therefore schools are in error for not postponing the teaching of fractions. While Payne is not misquoting any research study, it should also be recognized that other studies have shown that fifth-grade children are mentally able to begin the study of fractions.

Johnson (33) referred to research from which he concluded that addition and subtraction of fractions as parts of units should be limited to the oral manipulation of halves, fourths, and eighths. More complex manipulations would be eliminated, and their counterparts taught decimally. Decimals would then be taught earlier as a continuation of whole numbers and the United States money would be taught with emphasis on the concept of place value thruout. He recommended that time thus saved be used in teaching the relations of numbers and their ratios and factors, as expressed in their common fraction form. In another article (34) Johnson explained the use of ratio blocks in helping pupils gain the concept of a fraction as the relation of two whole numbers.

Solutions to problems in teaching arithmetic based upon the findings of the Chicago committee in 1938 were reported by Johnson (35). He cited experimental evidence which indicated that decimal fractions are easier to learn than common fractions, and pointed to the need for further experiments directed toward answering the question, "Can mathematical concepts be taught?"

Christofferson (15) suggested the use of problems to illustrate division by a fraction, and to provide suitable material as a springboard for plunging into the study of this phase of arithmetic. He included explanations of seven settings for giving meaning or common sense to the process. Those explanations listed under the headings, "Multiplying Dividend and Divisor by the Same Number," "Using a Common Denominator," "Series," and "Laboratory Experimentation—Using Actual Measures" seemed useful.

Points of view on the question of when to begin formal arithmetic instruction and drill were presented by Sauer (57) and Falk (2). The former advocated basing the arithmetic program on planned number experiences, with formal drill beginning in Grade III, at which time records of growth might be maintained on graphs. Grades IV, V, and VI would work with more difficult experiences, and the atmosphere of the arithmetic class would be similar to that of the social-studies class. Falk reported that as a result of the institution of an informal arithmetic program in kindergarten and Grade I and the beginning of formal instruction in Grade II rather than III, the children in San Diego schools were a year above the national norms. For the new program new workbooks and supplementary aids are provided.

Poritz (54) and Van Engen (68) discussed the strengths and weaknesses of teaching addition and subtraction by use of triads. Van Engen attacked the use of triads as mechanical and without meaning. Poritz replied that recognition of the relation of one number to the others in the triad is meaningful.

The teaching of place value in the first grade was recommended by Morton (47). This assumes, of course, that provision is made for counting, reading, and writing numbers as part of the curriculum of that grade. He favored Brueckner's method of teaching the meaning of the first number in relation to the second as in 11, by the use of the first-grade pocket or wall chart. Work with the chart in the primary grades provides experience which is a helpful basis for column addition and building multiplication facts. By using two pocket charts in the intermediate and upper grades the relationship between whole numbers and decimals may be shown.

A plan for presenting percent was advocated by Van Engen (66) who would greatly increase the amount of time spent on establishing ideas, terminology, and symbolism before attempting work on the cases. He suggested work on terminology (5 percent is 5 per hundred) for the development of a rate idea. In Grade VI, percent is presented as a ratio, gradually leading to the idea of hundredths. (He likened the three cases in percent to the formula for finding area of a rectangle ($A=bh$) wherein any one member may be determined when the other two are known.)

In another article Van Engen (67) urged the advantage of the caret method of placing the decimal point in quotients on three grounds: (a) the relatedness of decimal and common fractions, (b) its value in establishing a background for ratio, and (c) the necessity of the principle itself for the understanding of common fractions.

A method of self-instruction for learning the thirty-six addition combinations with sums from 11 to 18 and their corresponding subtraction facts in Grade II was described by Wilburn (72). His method involved regrouping (as changing 9 + to 10 + 8). The same author described (73) procedures which were successfully employed to assist 291 third-grade pupils in twelve schools to learn to use a ten in subtracting. "Using a ten in subtraction may be defined as the rearranging of a group of tens and ones so that a larger group of ones than exists in the original group can be removed."

In an extensive and carefully controlled experiment Brownell (9) secured data relative to the decomposition and equal addition methods of teaching subtraction; both were methods taught mechanically and rationally. The results warranted these conclusions: (a) if the decomposition method is to be taught, it should be taught rationally; (b) if the equal addition method is to be taught, either mechanical or rational procedures may be used; (c) equal additions taught rationally produced superior results on immediate- and transfer-rate tests, but decomposition taught rationally produced superiority on immediate and delayed accuracy and transfer accuracy tests; (d) unless methods of teaching are considered in experimental studies, no statement can be made regarding relative efficiency of working procedures. This last conclusion is very significant and should be considered when findings of earlier studies on decomposition and equal additions are reviewed.

Suggested devices, activities, and discussions of method, as exemplified by references (26) (32) and (70), were found in nearly every issue of *Grade Teacher* and *Instructor*.

Just seven articles pertaining to teaching are reviewed, two of which are bibliographies. Buswell (13) in his annual reports of selected references, listed fifty-eight titles in the field of arithmetic. In the other bibliography reviewed, Butler (14) presented annotations on fifty-one titles dealing with the improvement of reading in mathematics. Many of the articles and suggestions should be of value to the teachers of elementary-school arithmetic.

Lists of equipment and concrete illustrative and self-discovery materials deemed useful in the classroom were prepared by McSwain (45) and Sands (56) who also discussed the arithmetic program.

Dexter (20) classified the written problems in the four books of one series. More than a third of the problems were called possible but improbable while a fourth of the problems dealt with purely artificial situations. Less than 1 percent of the problems dealt with real situations as defined by Dexter.

Grossnickle (25) reported a study of the illustrations in each of the five books of eight different series of children's textbooks. All illustrations were classified as decorative, associative, and functional. The last class was subdivided into static and dynamic. The number of illustrations varied from an average of one for every 2.3 pages to one for every 5.6 pages. The most popular-sized illustration in every series occupied from 20 to 40 percent of a page. The percent of total pictures of the decorative type ranged from 8 percent to 1 percent of the total illustrations; associative illustrations varied from a high of 74 percent in one series to a low of 42 percent in another. Percents for the static functional ranged from 12 to 7 percent, and for the dynamic functional, from 46 to 11 percent.

II. Secondary-School and College Mathematics

In the areas of secondary-school and college mathematics, the articles reported in the literature were predominantly concerned with observations and experiences, and only a few descriptions of planned research were available.

After analyzing more than fifty college textbooks in general mathematics, Brown (5) concluded that the content varied from the traditional courses in algebra, trigonometry, and analytic geometry to selected topics in higher mathematics, and its applied fields. Brueckner (12) re-emphasized that we must consider the social phase in mathematics, and gave a selected annotated bibliography of materials and methods to help in the achievement of this goal.

After observing the mathematical difficulties of 7000 students in a Naval Training School, Gowan (24) noted that these students were low in ability to (a) recognize when an answer is unreasonable, (b) determine degrees of accuracy, and (c) accept the absolute necessity of having accurate answers.

Miller (46) outlined a course in arithmetic for the twelfth year and reported that it had proved to be just as worthwhile as any other high-school mathematics course.

An article by Kinney and Freeman (39) was concerned primarily with certain psychological principles, but the implications for methods and for organization of materials were also discussed. These authors pointed out that: (a) learning is a purposeful and active process and that mathematical principles and processes should be studied first in situations in which they have been or will be used; (b) learning is a reorganization of behavior and in the organization of learning experiences should develop out of the current status of individuals and should be planned on a long-time cyclical basis with arithmetic experiences extending beyond the eighth grade; (c) learning is by wholes, and that the planning should include an overview period, an assimilative period dealing with detailed aspects, and a summary period to bring the parts into relation again; and (d) learning is colored by feeling and emotion and that pupils should recognize the significance of what they are doing, should be given evidence of progress toward the goals, and should engage in activities related to their needs of the moment. Implications were discussed in connection with the organization of activities, the planning of repetitive learning, and the designing of a program of evaluation.

In its second report, the Commission on Post-War Plans (17) included among its theses several which were concerned with basic principles to be used in devising methods and in selecting materials. Pertinent suggestions were made concerning materials which should be included in the program for teacher training. Theses regarding multisensory aids were also developed. In another report (16), this same commission presented important guidance information for high-school students who are interested in the field of mathematics as a career. A bibliography was included.

In an investigation concerned with arithmetic problem-solving, Lyda (19) gave a set of thirty verbal problems to pupils in Grades VII thru XI. He then had five pupils from each of these grades work orally the three problems that had been missed by 96 to 100 percent of all the pupils tested. Numerous weaknesses were found in the various arithmetic abilities. These findings led Lyda to conclude that high-school students: (a) should be tested periodically with respect to the fundamental arithmetic operations; (b) should be given remedial teaching based on the test results; (c) should be retested; and (d) should be taught arithmetic and other problem-solving procedures in every subject, thus making every teacher an arithmetic teacher.

Albers (1) selected sixty-four pupils with Stanford Binet intelligence quotients of 125 or higher, and formed two groups of thirty-two each equated according to intelligence quotients, initial algebra achievement as determined by Form S, *Cooperative Algebra Test*, and chronological ages. She used one of these groups as an experimental group and one as a control group to study the advisability of providing enrichment material for superior students. An enrichment inventory test and an interest questionnaire were administered to both groups. Each pupil of the experimental group was given a booklet with the enrichment content and permitted to work on it during the extra time in the regular class period and also at home. At the close of the experiment, both groups were given another form of the algebra achievement test, the enrichment inventory test was repeated, and another interest questionnaire was administered. The results revealed that tho the experimental pupils had averaged about 15 percent less time on the regular algebra work, they made the same amount of improvement on the algebra achievement test as the control pupils. On the first enrichment test, the experimental group had a mean of 5.92 and the control group had a mean of 6.06; on the final enrichment test, the means were 20.28 and 7.88, respectively. For the total interest scores, the increase in mathematics-science interest was not statistically significant for the control group (critical ratio .68), but there was a statistically significant increase for the experimental group (critical ratio

3.72). Because the enrichment material was planned for self-administration and self-testing, it took very little of the teachers' time.

Recognizing that more emphasis must be placed on coordinating the work of elementary and secondary mathematics, Kinsella (40) selected ten basic relationships which are stressed in the meaningful teaching of arithmetic and translated these from arithmetic to algebraic context.

Stabler (61) recommended that a logically developed unit should be included in the course in algebra so that, among other things, pupils may have a brief introduction to postulate systems, may be shown that algebra can be developed from postulates, and may come to understand how rules can be unified and made more significant.

In order to determine the feasibility of a structural approach to geometry, Luchins and Luchins (43) introduced the concept of area to a VIB class by using this intuitive approach. In four forty-minute sessions, the pupils were able to discover how to find the areas of rectangles, parallelograms, triangles, and various types of trapezoids. They also taught the concept of area by the structural method to nine girls, ages five to nine, a high-school geometry class, and a college-freshman mathematics class and found that their technic of presentation consistently provided better understanding and assured more certain retention of formulas.

After carefully analyzing the logic involved in indirect proof in geometry, Lazar (42) discussed three methods of indirect proof and concluded that the method of inconsistency can be most readily rationalized and is most convincing psychologically. He included a lengthy bibliography.

Mossman (49) analyzed a number of short-cuts that are often taught in arithmetic and algebra and revealed several inherent sources of confusion. Hartung (28) and Hawkins (29, 30) presented selected annotated bibliographies in the area of secondary mathematics.

In discussing the planning of a program for the use of learning aids, Schorling (58) refuted numerous questionable procedures and then gave several basic ideas for improving the use of learning aids.

Jones (36) argued that multisensory aids must (a) give concrete embodiment to more abstract concepts, (b) must be applications that give added reality, and (c) must produce a better understanding of worthwhile mathematical principles. He then suggested a number of devices varying from an adjustable gangplank with parallelograms and triangles to devices that duplicate definitions of cissoids and trochoids.

Fehr (22) made several suggestions concerning the place of multisensory aids in the teacher-training program, and emphasized that if mathematical laboratory periods are provided, reality can be given to the subject without losing any of its abstract and theoretical aspects.

The "plus" phases that have been developed in the junior-high-school mathematics program in Washington, D. C. were reported by Schult (59). These include such activities as construction, dramatization, and collections. Sources of many materials were suggested.

Included in the report of the Committee on Multisensory Aids (18) were chapters concerned with drawing and design, demonstration and exhibit, models and devices, instruments and tools, materials for model construction, projection materials and equipment, and a historic discussion of models and devices. Each chapter included a bibliography.

The yearbook written by Kieley (38) was concerned with the history and the classroom use of surveying instruments. The historical information provided interesting enrichment material, and the numerous suggested applications are valuable for classroom use. A very extensive bibliography was provided.

Monthly descriptions and appraisals of learning aids were prepared by Syer and Johnson (65). These reports covered the latest booklets, charts, bulletin board displays, equipment, films, film strips, instruments, models, pictures, plans for construction, glass slides, sources of materials, and standardized tests.

Altho there have been numerous studies of the mathematics that students have retained, little attention has been paid to the mathematics which majors in this field have available sometime after study. Boeker (4) investigated the status of 131 beginning calculus students in respect to the pre-calculus mathematics which they had retained. She administered a test which included the fundamental ideas, basic concepts, and definitions from trigonometry, college algebra, and analytical geometry. In nine of the ten areas measured, a large percent of failures was found. Thirty percent of the students missed 74 percent or more of the 125 items in the test, and 92 percent of the students missed at least 30 percent of the items. Several specific suggestions were given for improving the basic work in pre-calculus courses, with chief emphasis on concept building.

To ascertain the relative merits of (a) posting test marks, (b) annotating test papers, and (c) supplying remedial work as a check on directed study, Weiden (69) conducted two consecutive twelve-week experiments. Posted, annotated, remedial, and control sections were equated according to mental ages, socio-economic status, and scores on the Breslich *Algebra Survey Test*. Thru the twelve weeks of each experiment, a brief test based on the work assigned for the directed study period was administered each day just before the close of the period to all sections except the control group. Percent marks were placed on the blackboard for posted sections, but no papers were returned. Annotated sections got each test back with annotations. Papers were returned to "remedial" groups, and special work was given to these sections during part of the following period. All sections were given other forms of the Breslich *Algebra Survey Test* at the end of eight and of twelve weeks. In the first experiment, the only statistically significant difference was between the annotated and control sections. In the second experiment, remedial sections had statistically significant gains over both the annotated and control groups. Questionnaires revealed that students liked the check tests, felt that they profited from them, and of the four methods used in the experiment the remedial method was preferred.

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CHAPTER V

Measurement and Evaluation in the Teaching of Mathematics and Science

ELSA MARIE MEDER and EDWIN EAGLE

IN THE period covered by this review, a number of reports have appeared having as their purpose the interpretation of research in various areas of testing. The Forty-Fifth Yearbook of the National Society for the Study of Education discussed procedures for measuring understanding, with chapters devoted to the measurement of understanding in elementary-school mathematics (53), secondary-school mathematics (22), and science (23), and with material on health education (46) and technical education (56) having implications for those concerned with evaluation in the science fields. The Forty-Sixth Yearbook of the National Society for the Study of Education (39) was devoted entirely to science education and included chapters on the evaluation of outcomes of science education on the elementary level and on the secondary level. Crawford and Burnham (6) surveyed materials designed to measure specific achievement, differential aptitudes, and unitary traits, and discussed the basic principles of constructing and administering objective tests. Frandsen (14) and Fowler (13) summarized research on measurement of interests. Wrightstone (60) identified the frontiers of research in the measurement of aptitudes and achievement.

Increased Use of Objective Tests of Achievement

There is evidence of an increased recognition of the fact that objective examinations can be appropriately used in connection with problem- and essay-type tests. Stright (51) recommended the use of objective and semi-objective tests in college mathematics classes, and published a sample calculus test of the objective type. Zant (61) reported on the multiple-choice type examinations in college algebra, analytic geometry, and calculus developed by the United States Armed Forces Institute for judging the achievement of students in service. Ashford (2), reporting to the Division of Chemical Education of the American Chemical Society, described the work of the Committee on Examinations and Tests in preparing objective tests in inorganic chemistry, qualitative analysis, quantitative analysis, organic chemistry, physical chemistry, and biochemistry. He emphasized the Committee's belief that objective tests alone could not form an ideal testing program, while pointing out the unreliability of essay-type examinations.

Basing his argument on psychological grounds, Krout (30) indicated the need for three-level achievement testing. He recommended the use of forms of controlled word association to measure student development on the perception-cognition level; multiple-choice or matching technics to measure development on the level of concept-formation, judgment, and reasoning; and essay-type tests to measure the formation of attitudes conducive to action in appropriate situations. Crawford and Burnham (6) pointed out that subjective appraisals of achievement together with the Carnegie Foundation's *Graduate Record Examination* yielded a better index of promise for advanced work than either predictor alone, and stated their belief that scholastic evaluation usually is most valid when both subjective and objective methods of appraisal are used.

Effects of Cooperation in the Preparation of Objective Achievement Tests

While cooperation in the preparation of achievement tests is by no means a new development, the participation and interest of subjectmatter instructors seems to have increased, with a resulting salutary effect on classroom instruction. The development of tests for the United States Armed Forces Institute enlisted the participation of many subjectmatter specialists (2, 61). According to Ryans (47), the Navy achievement-testing program showed that achievement tests can contribute to the improvement of course instruction. Participation in the development of examination questions helped instructors to identify areas of student confusion. Study of item analyses helped them learn wherein their instruction or the course syllabus was inadequate. The program contributed valuable supervisory information by aiding in the discovery of the extent to which schools were accomplishing their instructional goals. It also gave a basis for recommending revisions of curriculums, methods, and policies.

Ashford (2) reported that those who helped in the preparation of the American Chemical Society tests considered themselves benefited by both the necessity for continuous re-examination of aims, objectives, and subjectmatter content, and by the exchange of views with fellow teachers. As many as seventy-three chemistry instructors in sixty-one institutions cooperated in the preparation of a single examination. The Committee on Examinations and Tests of the Division of Chemical Education, feeling that the development of objective tests can have a definite effect on the improvement of teaching, invited the participation of all teachers of college and university chemistry courses in its work. Diederich (8), describing the comprehensive examination system of the University of Chicago, stated that the cooperation of course instructors with the examiners made the teachers unusually conscious of the objectives of the courses, and thus contributed to better teaching.

How Achievement Tests May Influence Curriculum Changes

Objective tests of achievement have sometimes been criticized as tending to preserve the *status quo* in education. Peterson (42), on the other hand, found justification for curriculum change in results obtained by the use of a carefully constructed objective test of achievement in physics and chemistry. Results of its administration in high-school chemistry classes, physics classes, and physical-science classes demonstrated the practicality of developing a one-year science course in which physics and chemistry are fused.

Ohlsen (41) found that the present mathematics curriculum of forty-three Iowa high schools was not effective in helping young people attain mastery of those mathematical concepts and skills accepted as essential for meeting satisfactorily the experiences of ordinary life. His conclusion was based on statistical studies of the responses of more than 2800 high-school students to test items designed to measure the skills and concepts defined by the Joint Commission of the Mathematical Association of America and the National Council of Teachers of Mathematics. The general proficiency index (percent knowing how to select the correct answer) was 48.2 percent; the indices for arithmetic, graphic representation, algebra, and informal geometry were respectively 57.8, 60.2, 29.2, and 49.8 percent. Analysis of items marked incorrectly indicated that the most common causes of error were (a) lack of understanding of the correct method of solving a problem, (b) confusion concerning related mathematical terms, (c) inability to select pertinent data, and (d) computational mistakes.

In a study concerned primarily with reading abilities in relation to success in mathematics courses, Eagle (9) found bases for recommending that the content of mathematics courses be selected and organized to emphasize methods of organizing and presenting data.

Measuring Problem-Solving Abilities

A trend in evaluation in science and mathematics education is increasing stress on outcomes other than memoriter learning of facts and principles. Diederich (8) pointed out that the University of Chicago examinations in the sciences never give more than 30 percent either of time or weight to recall of facts, but emphasize chiefly the use of facts in solving problems that have not been discussed in the courses. Smith (48) reported the relationship between the ability to reason about scientific facts, as measured by a particular test, general intelligence, and recall of scientific information. He found that scores on the reasoning test and scores on an informational test correlated to about the same extent with scores on a test of general intelligence ($r = .580$ and $.585$ respectively), and that scores on the reasoning test and scores on the informational test were more closely related ($r = .770$).

Spache (49) constructed an arithmetic-reasoning test designed to measure ability to (a) recognize or understand the facts given, (b) decide what facts must be found to solve a given problem, (c) choose the appropriate arithmetical computation, (d) estimate a probable answer, and (e) execute a solution. The test was administered to 158 pupils in the fifth and sixth grades and is currently undergoing revision on the basis of item analysis and intercorrelations of the subsections. Study of the 27 percent of the respondents with the highest scores and of the 27 percent with the lowest scores showed that those in the low groups also had lower scores on a test of general ability, on experimental tests of reading and writing numbers, signs, and symbols, and of arithmetic vocabulary, and on a test of arithmetic fundamentals.

Lyda (32) recorded the words and actions of thirty-five pupils in Grades VII thru XI as they tried to solve out loud realistic verbal problems in arithmetic. An analysis of the records indicated that important causes of difficulty were inability to analyze a problem to find out what is required, what information is given, and how the data may be used; inability to outline a method of attacking a problem; a tendency to manipulate figures without understanding; inability to check the reasonableness of a solution; and computational difficulties. He also reported (33) that ability to solve realistic reasoning problems appeared to be positively related to general intelligence.

In measuring understanding and judgments in arithmetic, Sueltz (52) used objective materials, such as pieces of paper to be divided in half by lines, and circles whose areas were to be compared. He also prepared more than 400 multiple-choice test items, many of which were accompanied by sketches. Between 300 and 400 pupils in Grades IV to IX responded to the items. Groups of students were interviewed in order to identify the procedures they used in arriving at answers. The investigator found that formal computations seemed to be a stumbling block to the development of judgment; that the desire to compute glossed over the elements of understanding.

As a result of interviews with forty-four children four and five years old, Mott (38) reported that children of the age studied can readily master the names of numbers and reproduce them in any sequence; that about 92 percent of the children have concepts for the numbers one to ten; that about 72 percent recognize the first five ordinals and 64 percent can reproduce them, while 66 percent recognize and 20 percent can reproduce the first ten ordinals; and that the children can add and subtract readily when playing with blocks. Of the twenty-three children about to enter first grade, 90 percent counted by rote to ten, 82 percent to fifteen, 50 percent to twenty, and 22 percent to one hundred. Stotlar (50) held interviews of the same pattern with nineteen children four and five years old. She found no marked difference between counting by rote and counting objects; 70 percent of the group could count to ten or above both by rote and by concept. All the children were conscious that there were such things as written numbers.

In the science field, Oakes (40) asked for explanations of natural phenomena from thirty-five college faculty members, all of whom held at least a master's degree in some field other than science. These adults exhibited very little in the way of a consciously reflective or logical procedure in attacking unfamiliar problems.

Measuring Abilities Involved in Generalizing

The ability to generalize was investigated by Ebert (10), who found a positive correlation with mathematical proficiency. He asked approximately 900 eighth-grade students: (a) to give an illustration of a mathematical relationship that was similar to several illustrations analyzed; (b) to write a statement in words of a general truth represented by several given illustrations of a mathematical relationship; and (c) to express in written form a specific illustration of a general truth in elementary mathematics that had been studied in verbal form. He found that the most difficult of the three tasks was the second.

Similarly, Alpern (1) found that to suggest procedures for testing hypotheses seemed more difficult for high-school science students than to select such procedures. The ability to suggest ways of testing hypotheses, as evidenced by 248 students, appeared to be related to the habit of delayed responses, altho this relationship could not be definitely established. The ability of 448 high-school science students to select procedures for testing hypotheses was not significantly related to chronological age, general intelligence, reading ability, sex, or the number of terms of high-school science study.

The ability to test hypotheses is one aspect of what is frequently called scientific method. Another aspect is the ability to formulate hypotheses in accord with the facts. Roody (45) devised a test, intended for use in high-school English classes, aimed at measuring progress toward realistic thinking. She invented a number of story plots, each with five endings. One of the endings contradicted the facts given; one was contrary to natural laws; two were possible; and one was exaggerated or morbid.

Testing the Ability to Apply Principles

The ability to apply principles was measured by Wise (59), who prepared a series of unit tests in physics which were administered at the close of units of study in seven Nebraska high schools. Each test of ability to apply principles in practical situations was accompanied by a test measuring recall of the principles and ability to perform related computations. Results on the applications-of-principles tests and on the tests of recall were related about equally to scores on general intelligence tests, but the relationship had no predictive value. Wise concluded that the traits associated with application of principles were not identical with those associated with recall and computation.

Thelen (54) also attempted to measure the ability to apply principles of physical science. He broke down this ability into several aspects; for example, to recognize a new application of a known principle, to rate statements as useful in explaining events, and to predict results of action. His testing technic utilized film slides and synchronized recorded sound, and achieved more realistic test situations than was possible with pencil-and-paper tests where facility in the manipulation of verbal symbols is a factor masking the nonreading abilities to be measured. The new technic included these steps: the title of a problem was projected on a screen and stated by the narrator (on a record); a situation was depicted and described; possible responses were presented in pictures and statements; directions were given by the narrator, who paused to allow the respondents to indicate their responses on answer sheets. This study was exploratory, and the investigator did not attempt to draw conclusions concerning the ability to apply principles, altho he found some evidence of increasing maturity of thought (from fifth to tenth grade) related to learning experiences. He pointed out these advantages of the testing technic: (a) uniformity of administration; (b) high motivation of the respondents; (c) minimization of the verbal element with increased validity of testing nonverbal objectives; (d) the possibility of appraising some fairly sophisticated objectives at a low-grade level.

Another attempt to approximate actual situations was made by Hendricks (24) in connection with laboratory work in chemistry. He developed test items based on diagrams and computed their validity by the use of associated items from a laboratory performance test. His validity indices ranged from .29 to .50 for items designed to measure objectives such as these: (a) Can the student read a measuring device with the required precision? (b) Can he bring the proper pieces of apparatus together for doing an assigned laboratory task? (c) Does he anticipate the effect of the change in conditions upon the outcome of his experiment? (d) Can he correctly select apparatus for processing substances in terms of their differing heat constants?

Robertson (44) reported a type of chemistry examination designed, as he stated it, "to distinguish laboratory thinkers from cookbook slaves." Students were asked to write directions, suited to a person of their own experience, for performing a given laboratory task, such as the isolation of a pure compound from a specified mixture. The use of handbooks and textbooks, but not laboratory manuals and private notebooks, was permitted.

In his report on the Navy testing program, Ryans (47) stressed the need for careful attention to measuring the actual objectives of instruction. He pointed out that it was more important to differentiate between "can do" and "cannot do" than to distinguish between "knows how" and "does not know how," and stated that performance tests were developed to measure achievement on the operational level.

The Importance of Reading Skills

A comparison of reading scores with grades in chemistry and physics, made by Krathwohl (28) showed a clear relationship between the reading ability of college freshmen and success in lecture courses in chemistry and physics. Of those whose reading scores were in the lowest fourth of the 1118 students tested, 64 percent failed chemistry or physics, and only 7 percent made honor grades. Of those with reading scores in the highest fourth, 24 percent failed, and 45 percent made honors.

An extensive study of the relation of certain reading abilities to success in mathematics was reported by Eagle (9). He determined success in mathematics by averaging the arithmetic reasoning and arithmetic computation scores on the *Stanford Achievement Test* with semester marks in eighth- and ninth-grade mathematics courses, and identified the effects on success in mathematics of these factors: mental age, reading comprehension, reading speed, general reading vocabulary, mathematics vocabulary, ability to interpret graphs, and ability to interpret algebraic formulas. Standard tests were available for the first four factors; tests were especially prepared for the last three. After partialling out mental age, it was found the mathematics vocabulary, the ability to interpret graphs, and the ability to interpret formulas were the factors most closely related to success in mathematics. There was no evidence in this study that improvement in general reading comprehension or general vocabulary would increase proficiency in mathematics. With respect to success in plane geometry, however, Truesdale (58) found that predictions of a grade of A or B in geometry could be made for 25 percent of all students with ninth- to eleventh-grade reading ability and for 50 percent of all students with twelfth- or thirteenth-grade reading ability.

Diagnosis and Remedial Instruction

There is no sharp dividing line between achievement tests and diagnostic tests. Traxler (57) stated that very few of the available tests in secondary school mathematics have extensive diagnostic features, but pointed out that teachers can make rough diagnoses from responses to individual items.

Tilton (55) administered *Compass Survey Tests in Arithmetic* to 138 fourth-grade pupils, and selected thirty-eight pupils showing a year's retardation for a controlled experiment on the effects of small amounts of individualized instruction. Nineteen of the children were given the *Los Angeles Diagnostic Test* and four weekly twenty-minute periods of remedial instruction based on the results. Three weeks after the last period of instruction, the entire population of 138 fourth-graders took another form of the *Compass Survey Tests*. Those children who had had remedial instruction showed a retardation of only seven months as against the twelve months' retardation of the control group. Burton (3) also found that remedial instruction in arithmetic resulted in improved test scores. He worked with high-school juniors and seniors who scored below the fiftieth percentile on the Schorling-Clark-Potter *100 Problems Test*, and found that the group of forty who accepted remedial instruction improved by 17 percentile points while the group who had no remedial instruction improved by only 3 percentile points. Mahin (34) administered the *Stanford Achievement Test* to 142 high-school students who were either in the senior class or seventeen years old, and found that ninety-four failed (scored below 78). After twelve weeks of remedial work, sixty-six of the ninety-four passed a retest. Error analysis indicated that percent and division problems were most likely to be done incorrectly.

Guiler (17, 19, 21) analyzed the responses of 936 ninth-grade pupils to the Christofferson-Rush-Guiler *Analytical Survey Test in Computational Arithmetic*, and found that many errors could be attributed to lack of understanding of correct procedure as well as to computational mistakes. On the part of the test dealing with fractions (19), weakness in addition was evidenced by 23.0 percent, in subtraction by 42.5 percent, in multiplication by 42.5 percent, and in division by 40.7 percent. On the part of the test dealing with decimals (17), weakness was manifested as follows: changing fractions to decimals, 60.7 percent; changing mixed numbers to decimals, 82.7 percent; addition, 33.0 percent; subtraction, 33.3 percent; multiplication, 6.6 percent; division, 83.9 percent. On the part of the test concerned with percents (21), difficulties were encountered by 51.6 percent of the pupils in finding a percent of a number, by 47.7 percent in finding what percent one number is of another, by 94 percent in finding a number when a percent of it is known, by 72.2 percent in finding the result of a percent increase or decrease, and by 88.2 percent in finding a percent of increase or decrease. The over-all picture was very similar when the same test was administered to 925 freshmen in Miami University (16, 18, 20). The college freshman did considerably poorer on the fractions (percents showing weakness ranged from 44 to 63), somewhat better on the decimal part (6 percent to 64 percent), and about the same as the ninth-grade students on the percent problems (50 percent to 88 percent).

Kinzer and Fawcett (26) reported on an arithmetic test given to students at Ohio State University who elect beginning chemistry, comprised of fifteen problems involving the reduction of fractions to their lowest terms, the conversion of fractions to decimals, finding the missing term in a proportion, the computation of a percent, a verbal problem involving ratio and proportion, and a problem involving exponents. Of the 1439 students tested in the fall of 1945, 534 had less than one-third of the problems correct. These students were given an opportunity to participate in remedial sessions ninety minutes in length, held twice weekly for three weeks. At the end of this time, those taking remedial work were retested. Their scores on the retest ranged from 8 to 92 percent with an arithmetic mean of 52 percent. The remedial work appeared to have a definitely beneficial effect on success in chemistry, for no student who received 85 percent or higher on the retest received less than a C in his quarter's work in chemistry.

Investigations of Interests and Beliefs

Morton (37) studied questions about aviation collected from 3262 children in Grades I thru VIII. Of nearly 22,000 questions, 6410 had mathematical connotations. These were used to ascertain appropriate grade placement of arithmetic topics. The outstanding interests in all grades were in size, quantity, and time, including speed. Money in relation to aviation was of interest in all grades except the first and third; direction, in the third, sixth, seventh, and eighth grades; position and instrument reading, in the sixth and seventh grades; and pressure, in the eighth grade.

From a comparison of the responses of ninth-grade students to statements on a written test of superstitions and to situations in which actions might be conditioned by superstitious beliefs, Zapf (62) concluded that a paper-and-pencil test could be considered an adequate measure of superstitious beliefs. The paper-and-pencil test was given to 1135 ninth-grade students, and the results were compared with other factors (63). Girls were found to be significantly more superstitious than boys, and children of low IQ more superstitious than those of high IQ. There was a slight but significant decrease in superstitiousness with increase in length of science study. More superstition was found among those of low economic level than among those who were comfortably situated economically. There was evidence that pupils who were superstitious were poorly adjusted to other pupils, and a correlation of .50 was found between superstition and suggestibility.

Ralya (43) administered a check list of 180 statements concerning human nature to 141 college seniors in a premedical curriculum. About 67 percent of the students accepted the statement that the average white man is born intellectually superior to the average man of other races, and about 33 percent accepted the statement that the average man is born intellectually superior to the average woman. In general, physical indices such as those accepted by the adherents of phrenology and palmistry were believed by between 18 and 48 percent of the students to reveal traits of personality and character. There was usually some difference between the beliefs of the forty students ranking lowest scholastically and the forty ranking highest; for example, 30 percent of the low group accepted a traditional statement of phrenology that only 8 percent of the high group accepted. However, there was no difference between the groups with respect to a statement based on astrology; 20 percent of each group accepted it.

Prognosis and Guidance

Kraft (27) reported the general satisfaction of algebra and geometry teachers in Cleveland with the procedure for selecting their pupils, in which scores on the *Iowa Algebra Aptitude* and the *Iowa Plane Geometry Aptitude* tests were used to classify pupils into "surely," "maybe," and "no" groups, and evidence such as previous success in school was used to move students from the "maybe" group to one of the other groups. When students were permitted to take the courses on other bases such as parents' wishes, grades were poor. In one instance, eleven pupils took geometry despite low aptitude test scores; seven of them failed the course and four received a mark of D.

Davis and Henrick (7) found that the best single measure of several considered for predicting success in plane geometry courses was the *Stewart-Davis Test of Ability in Geometry*, and that a test on algebra fundamentals was almost as good. The two tests combined had a very high predictive value: combined scores and success as measured by teacher-made achievement tests and the *Orleans Achievement Test* correlated to the extent of .95. Marks in eighth-grade arithmetic had a lower predictive value ($r = .59$). Challman (5) administered a Navy test of twenty arithmetic items and a specially prepared algebra test of twenty problems to 107 high-school geometry students at the beginning and near the end of the school year. The gains in arithmetic and algebra while studying geometry were significant, and correlations between final achievement in geometry and the various test scores led to the conclusions that ability in the performance of arithmetic and algebraic processes was one factor associated with achievement in plane geometry. Truesdale (58) reported that marks of A or B in plane geometry could be predicted for 10 percent of all students with arithmetic-placement scores in Grades IX thru XI, and for 40 percent of the students with arithmetic-placement scores in Grades XII and XIII. Holzinger and Swineford (25) found that spatial and general deductive factors could be measured and had greater value for predicting achievement in plane geometry than a teacher-made test administered after ten weeks of instruction.

When Krathwohl (29) compared success in college algebra, analytical geometry, differential calculus, and integral calculus courses with scores on the *Iowa Mathematical Aptitude Test*, he found correlations of .61, .52, .59, and .45, respectively, and concluded that the aptitude test had definite predictive value even two years after it was administered.

Meyer (35) studied the college achievement of students whose marks in high-school chemistry had been higher than their marks in other high-school subjects. He found that their marks in college chemistry were consistent with their marks in other college subjects, and saw no justification for excusing students from college general chemistry because they had had high-school chemistry. On the other hand, a more extensive study reported by Garrett (15) described a method of selecting students for advanced standing in chemistry. For several years, all students at Ohio State University who registered for chemistry after having had high-school chemistry were given a test covering the general physical and chemical concepts, a test covering the first quarter's work in college chemistry, and a laboratory performance test. Scores on these tests, together with intelligence test scores, provided a basis for granting or withholding advanced standing. Study of the results of this procedure led to the replacement of the test on general concepts and the laboratory test by a short test on arithmetic. About 1500 students take the tests each fall, and from 5 to 15 percent are allowed to proceed directly to the second quarter's work in chemistry. The marks of 365 of these students were compared with the marks received in the second quarter's course by 904 students who had been required, on the basis of the same selectors, to take the first quarter's work. Of those given advanced standing, 80 percent received marks of A or B and 1 percent failed; of those not given advanced standing 28 percent received A or B and 11 percent failed.

In forecasting achievement in pharmacy courses, Moore (36) studied the predictive value of scores on a pharmacy mathematics test, a pharmacy problem-solving test, science-survey tests, the *Iowa Chemistry Aptitude Test*, and percentile ranking in high-school classes. She found the best predictor to be a combination of the mathematics test, a science-survey test, and high-school rank.

Identification of Special Ability

An attempt to discover the personality traits associated with mathematical ability was made by Cattell (4), working with 123 adult males in the Army Specialized Training Program. Carefully controlled ratings on thirty-five personality trait clusters were correlated with measures of mathematical and verbal ability obtained from scores on the *Graduate Record Examination*. The correlation of personality traits with mathematical ability was much the same as their correlation with verbal ability. Highest positive correlations were found with clusters designated as intelligent, analytical, wise, mature, strong-willed, conscientious, intellectual, wide interests, smart, and assertive. Highest negative correlations were found with the following traits: changeable, frivolous, character neuroses, psychopathic, infantile, demanding, changeable, and characterless.

According to Long (31), the relationship between interests as measured by the *Strong Vocational Interest Blank* and scientific ability as measured by the *Zyve Scientific Aptitude Test* was not sufficiently marked to permit prediction of the Zyve score even from the rating on the technical mathematics scale of the Strong blank. However, the results indicated that the Zyve test measures some factor that separates those with interests in technical mathematics from those with technical nonmathematical interests.

Edgerton and Britt (11) reported on technical aspects of the fourth science talent search. Four discriminators were used to select the forty winners from the 2746 students who filed complete entry data; a scientific-aptitude examination, high-school record, teachers' recommendations, and the ratings of three judges on a science essay. Partial regression coefficients showed that the aptitude examination and the essay carried practically all the linear discrimination. The aptitude examination consisted of two parts. The first part contained fifty multiple-choice items, each with four possible responses. The items were designed to reflect the general breadth of interest in various areas of science and the ability to deal effectively with scientific materials. The second part was a paragraph-reading test, in which questions on reading were asked which could be answered by inference or reasoning from the information in the paragraph. The intercorrelation of the parts averaged .58. The total scores were found to be independent of the amount of mathematics taken or the number of science courses in which the students had enrolled.

The activities of all contestants in the first two science-talent searches, held in 1942 and 1943, and of all contestants who received honors in the later searches, are being followed annually by means of a mail questionnaire. Edgerton, Britt, and Norman (12) recently reported a study of the responses of boys who took part in the first search to the first three annual questionnaires. The data indicated that the boys selected for honors actually tend to be superior to those not so selected in terms of the following objective criteria: majoring in science; extent of education; college grades; honorary societies; scholarships or fellowships; and choice of professional field. The investigators stated their belief that the evidence so far obtained indicates that the science-talent searches are effective in selecting youth of scientific talent.

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CHAPTER VI

Teacher Education in Science and Mathematics

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VERY little research on the problems of teacher education in science and mathematics is available for the period of this review. Preparation for the writing of this chapter included an exhaustive survey of the professional journals and published studies. Letters requesting information on research completed or underway were sent to every college and university in the United States that maintains a graduate school or department of education. The majority of these graduate schools responded, yet few investigations in teacher education were reported. Of the studies completed during this period, or now in process, fewer still could be classified as objective research. Many of the studies included rest more on assumptions than on empirical data.

Criteria Basic to Teacher-Education Programs

Palmer (9) traced trends in the education of science teachers with particular regard to natural resource utilization. Part of Palmer's report was based upon research done by David Turner who visited practically all the training centers for work in wildlife conservation in the United States and Canada. As a result of about 800 questionnaire responses obtained from workers representing twenty-nine categories of the conservation program, he found the areas of training generally believed to be essential for effective conservation activities. Palmer conjectured that this study revealed one important source of objectives for the education of science teachers.

Richardson (12) examined the literature and reviewed certain outstanding problems to be faced in the education of science teachers. Unfortunately he did not provide a bibliography of the references he indicated were reviewed as a basis of his observations. Among the teacher-education problems Richardson listed are the following: (a) Prospective science teachers appear to exhibit a lack of understanding of the social function of science. (b) They tend to think in terms of subjectmatter boundaries rather than in terms of functional areas. (c) They largely accept as a single goal the imparting of information. (d) Most teachers in preparation have a very limited conception of the function of the laboratory in the learning situation. (e) They lack knowledge of available teaching resources.

Burgess (4) reported the procedure followed in Cleveland to determine the college courses in science and science education needed by elementary teachers. A working committee utilized a questionnaire to determine the needs of elementary teachers for content and experience areas. Brandwein (2) reported the beginning stages of the building of a curriculum in Forest Hills High School, New York, for students anticipating four years of science. This program was arranged from a functional point of view and was student-teacher planned. Chemistry, physics, biology, and other areas of science are utilized as required in order to solve the problems undertaken by the students. This experimental curriculum is reported in this section of the REVIEW as representative of trends in science teaching requiring modified programs of teacher preparation. Brandwein summarized as follows: "If the type of teaching which deals with problems of living is desirable, then we need wide and drastic changes in teacher training. Teachers who participate in a program focused on problems of living must know more subject matter, more of the behavior of adolescents, than those who concern themselves merely with subject matter."

Explorations similar to the foregoing have been conducted in regard to the preparation of mathematics teachers. The Commission on Post-War Plans created by the National Council of Teachers of Mathematics (8) issued its second report consisting essentially of theses concerning the preparation of mathematics teachers in Grades I to XII. Two of these basic concepts, from study of the literature, general policy statements, and the experience of the members of the commission, follow as examples of the general type of statements given in the report. (a) Courses in mathematical subjectmatter for the prospective mathematics teacher should be professionalized. (b) It is desirable that a mathematics teacher acquire a background of experience in practical fields where mathematics is used.

Status and Trends in Teacher Preparations

Maaske (7) analyzed the literature and reported trends concerning preservice education of teachers. The study included teachers of all fields. He concluded that orientation and survey courses in the sciences, as well as in other areas, are increasingly providing the general education base on which the subjectmatter specialization of the teacher is being built. In contrast with this trend, Crowell (5) described changes in science education at the State Teachers College at Trenton, New Jersey. As a result of opinion polls of both students and faculty, survey courses were modified and retained for elementary teachers and abandoned for those planning to teach academic subjects in high schools. For this latter group the survey type of course was replaced by separate subjects such as descriptive astronomy and geology. Other trends reported include increased first-hand experience for student teachers, and increased emphasis on laboratory and field work.

As a result of his study of the literature on the topic, Breslich (3) presented observations concerning the preparation of high-school mathematics teachers. Fawcett (6) pointed out trends in the education of mathematics teachers and discussed characteristics necessary for effective teaching and the nature of the preparation of mathematics teachers designed to result in such characteristics. Reeve and Howard (11) traced the trends and problems in teacher training in mathematics, particularly in student teaching. The literature and the student-teaching programs in various schools were the sources of their observations.

Prall (10) analyzed state programs for the improvement of teacher education carried out by the Commission on Teacher Education of the American Council on Education. Programs are reported in broad outlines. As an example, West Virginia has a single basic curriculum for both elementary and secondary teachers that includes six hours of biological science (integrated course) and the same for the physical sciences. This single curriculum leaves forty-one hours for electives. The secondary-science teacher must complete courses in his two teaching fields within these forty-one hours.

Walter (13) established an experimental group of student science teachers at Teachers College, Columbia University, and made a thoro analysis of the results of the experimental program. Certain basic concepts, such as "Student teaching should afford contact with all the important phases of a teacher's activity (both in and out of school)," were tested. According to the conclusions of the investigator, all concepts tested were found to be sufficiently rewarding to merit a marked modification of the traditional program of student teaching.

In a study of the certification requirements of elementary-school teachers in sixteen states, Blyler (1) found the minimum number of semester hours of mathematics required was two, the maximum five, and the average 3.4 hours. The minimum of science required was two, the maximum twenty-one, and the average nine semester hours.

Problems Needing Investigation

It is disconcerting to find that so few studies related to the education of teachers of mathematics and science have appeared over the past few years. Studies are needed on the determination of objectives of teacher education. Curriculum patterns should be developed and experimentally checked for adequacy. Little is known of optimum patterns of general education as background for mathematics and science teachers, of optimum structuring of content courses to provide the breadth and understanding needed by prospective teachers within the rigorous time limitations imposed by four- and five-year programs. We do not know, as fully as we need to know, what sorts of professional education and instruction in science and mathematics curriculum and instruction are soundest.

Over the past decade many studies have been made of the judgments of graduates from teacher-preparation institutions regarding their training. The products of our institutions have presented rather consistent patterns of objections to certain aspects of their preparation, yet little has been done to evaluate the modified programs as they have developed. It is hoped that the next issue of the REVIEW, devoted to the natural sciences and mathematics, will report much richer sources of valid studies on significant issues in teacher preparation than are now available.

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FOREWORD

THIS issue of the REVIEW, the fifth devoted to methods of research and appraisal in education, follows the pattern of summary and review used in the third and fourth cycles published in December 1942 and 1945, respectively. Limitations on space allowed for various chapters have required selective rather than complete discussion of all research studies published during the three-year period. Contributors to this issue have charted the significant trends, and have frequently indicated their critical estimates of studies. Their generous contribution is acknowledged.

Trends of special importance in methods and technics of educational research which have become more apparent in the three-year cycle covered by this issue of the REVIEW are presented in summary form in appropriate chapters. Bibliographic and documentary research has been characterized by enlarged and improved bibliographic guides and critical evaluation by experts of the canons of historiography. In diagnostic and synthetic studies of individuals, the trend has been toward the use of projective technics, including sociodrama and the nondirective interview, for research in personality. In trend, survey, and evaluation studies increasing activity has occurred in the construction and application of informal technics to appraise the less tangible objectives of education and in follow-up studies. Research methods have shown an increasing use of appropriate logic of induction for the sampling used and more efficient experimental designs based upon analysis of variance methods. Observational methods of research have revealed improved technics in analysis of documents, rating methods, opinion surveys, and observational instruments and aids. In tests and measurements, advances were made in technical construction of tests, more adequate measurement of long-established objectives, and the distinction between measurement of detailed subjectmatter content *versus* evaluation of general educational outcomes. Recent developments in statistical theory emphasize statistical technics of factorial design rather than those applied to studies using the so-called "law of the single variable." Articles on computational technics have increased in number rapidly during the three-year period covered by this review.

One member of the committee indicated the following problems which should receive increased attention and effort from research workers in this field. Briefly, these problems are: (a) an analysis, description, and history of trend, survey, and evaluation studies in recent years; (b) a definition of appropriate methodology for evaluation; (c) an analysis of studies in education which deal with what is desirable or what should be done in educational research; and (d) a comprehensive and critical review of educational tests—perhaps an entire issue of the REVIEW devoted to this topic. These suggestions indicate some of the unfinished work that offers a challenge to research workers.

J. WAYNE WRIGHTSTONE, *Chairman*
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CHAPTER I

Library Resources and Documentary Research

CARTER V. GOOD

THE description of library resources, bibliographical technics, and documentary research presented by Scates (71) in the December 1945 number of the REVIEW and by Good (37) in the December 1942 issue is carried forward in this chapter. The topics treated include: (a) library functions, organization, cooperation, and resources; (b) general treatises or manuals on library aids and technics; (c) guides to periodicals and books; (d) encyclopedias and dictionaries; (e) guides to theses and selected research projects; (f) serial and occasional bibliographies and summaries; (g) institutional and biographical directories or handbooks; and (h) historiography in history proper, education, psychology, sociology, philosophy, science, and related fields.

Library Functions, Organization, Cooperation, and Resources

Butler and others (17) analyzed the reference functions of the public, school, college and university, and research libraries, with special attention to problems in art and music, map collections, social sciences, science and technology, the humanities, administration, and in personnel and training. Wilson and Tauber (82) described established practice in library organization and administration, with a few critical comments on controversial issues or practices. Davidson and Kuhlman (25) outlined briefly the growing movement toward development of library and research resources in certain cooperative university centers of the South. Evans (31) described the national bibliographical services of the Library of Congress thru its facilities, collections, and experience, which have developed over a period of a century and a half.

Downs (27) emphasized the fact that international understanding is based on free interchange of the cultural records of nations as collected and preserved by libraries, educational institutions, and cultural organizations in general. International exchange of resources involves a number of possibilities and problems such as (a) exchanges between institutions; (b) exchange of government publications; (c) national bibliography; (d) reproduction of research materials; (e) coordination of book acquisitions; (f) reconstruction of foreign libraries; (g) copyright, tariff, and postal regulations; (h) translations; (i) exhibits; and (j) interchange of personnel.

Verdoorn (79) defined the chief aims of international scientific cooperation as exchange of information, attainment of objectives which scientists of a single institution or nation cannot accomplish alone, and development of an *esprit de corps* which may counteract the evils of human international politics. He identified the means by which these aims may be approached as: (a) various forms of cooperative research, (b) international conferences and congresses, (c) activities of international commissions and committees responsible for the solution of specific problems, (d) personal contacts, visits, and correspondence, (e) exchanges of research materials, specimens, and literature, (f) exchanges of professors, research workers, and students, and (g) various publications (for example, scientific journals, abstracting journals, textbooks and reference books, popular books and journals, directories, and bibliographies and indexes).

General Treatises or Manuals on Library Aids and Technics

Winchell (83, 84) prepared the third and fourth supplements to the sixth edition of Mudge's *Guide to Reference Books* (62), covering periodicals, newspapers, societies, essays and general literature, dissertations and research projects, encyclopedias, dictionaries, philosophy and psychology, religion, social sciences, science, useful arts, fine arts, literature, biography, geography, history, government documents, and bibliography. Barton (7) prepared a brief guide to reference books, and Bryan (16) an even smaller key to professional information, intended primarily for teachers. The third edition of Alexander's standard text and reference book on educational information and data is scheduled to appear in the near future.

Guides to Periodicals and Books

Beginning with the educational books of 1947, an annual compilation of outstanding publications appeared in the *Phi Delta Kappan* (20), after having been published for many years in *School and Society*; this annual list of educational books identifies sixty volumes adjudged especially significant. Witmer (86) compiled a list of important books in education for 1945 and 1946, and Bay (9) characterized briefly important books in science for the past century.

The Bibliographic Index (35) cumulated for 1943-1946, and the fifth edition of Ulrich's *Periodicals Directory* (78) appeared. Hirshberg and Melinat (49) selected those books and pamphlets, published for the most part during the past twenty years, believed to be most generally useful in libraries, with emphasis on serials, directories, bibliographies, and handbooks which have greatest potential reference use. This compilation is a simplified, practical approach to the complexity of government documents, and provides a key to the wealth of information found in federal government publications, especially for the selective depository libraries and the smaller public and college libraries.

Encyclopedias and Dictionaries

The forthcoming revised edition of the *Encyclopedia of Educational Research* (61) will be considerably revised and enlarged. Kaplan (52) edited two volumes on guidance, not encyclopedic in the usual sense, but a compilation of discussions on major topics, interspersed with short articles, with emphasis on major occupations and the rise of aptitude and specific vocational tests.

Carmichael (19) edited an advanced textbook or reference work on some of the most important aspects of research on human development and child psychology. The bibliographies are extensive, with emphasis on the period since 1933. This manual is a sequel to the *Handbook of Child Psychology* (64) edited by Murchison.

Harriman (45) edited a volume of 100 signed articles, alphabetically arranged, on a miscellaneous variety of topics in the field of psychology. His title of "Encyclopedia" for this volume is misleading. Because of incomplete coverage of the subject, disproportionate treatment of subjects in comparison with their importance, and inadequate indexing, this volume will prove less satisfactory for reference purposes than the psychological handbooks and dictionaries.

Thornton (74) presented a proposal for an encyclopedia of psychological information, to embody the following features:

> (a) a complete index in one volume of all psychological topics; (b) reviews of all important areas in psychology, each review written by an authority in that area; (c) complete bibliographies on all important topics in psychology, with the most significant references starred; (d) cross-references between related areas; (e) provision for correction of errors by the readers as well as the editors; (f) development of a normative dictionary of terms to simplify the task of communication of ideas thru the encyclopedia; (g) frequent revision and supplementation of reviews, bibliographies, cross-references, and index in order to incorporate the results of new researches and to eliminate errors that have been discovered.

Runes (68) edited a relatively brief volume, attempting to provide definitions thruout the range of philosophic thought. Unusual in the annals of professional writing, ten contributors disapproved the work as published, altho a number of good individual articles and definitions were included. New dictionaries of psychology (46) and of social welfare (88) appeared.

Guides to Theses and Selected Research Projects

The annual compilation of *Doctoral Dissertations Accepted by American Universities* (77) continued under the editorship of Trotier. The list of doctors' dissertations under way in education appeared in the *Phi Delta Kappan* (38, 39), after having been published for many years in the *Journal of Educational Research*. Other compilations of graduate dissertations covered: sociology (3, 4), history (2), political science (32), library science (22), and Negro education (55). Bowers (12) continued his annual census of research projects in sociology.

Serial and Occasional Bibliographies and Summaries

The annual bibliography on the methodology of research appeared in the *Phi Delta Kappan* (41, 42), after publication over a period of years in the *Journal of Educational Research.* Other serial bibliographies or summaries covered were: reading (44, 76), teacher supply and demand (30), Negro education (56), and history and philosophy of science (70). Selected occasional bibliographies or summaries were published in the areas of guidance (48), mental measurements (47), character education (54), juvenile delinquency (18), and radio research (58).

Institutional and Biographical Directories or Handbooks

Standard guides to higher institutions included the fifth edition of *American Universities and Colleges* (15) and the second edition of *American Junior Colleges* (11), as well as the *College Blue Book* (51). *A Guide to Colleges, Universities, and Professional Schools in the United States* (40) was prepared especially for returning veterans interested in higher education; it attempted a complete coverage of collegiate and professional institutions and was arranged in tabular form for ease of reference.

Bates (8) described the origin, functions, and national contributions of scientific societies, based on publications of the societies, and on other sources such as biographies and memoirs. Visher (80) analyzed the characteristics of scientists starred in *American Men of Science*, and Hughes (50) made a study of graduate schools conferring the doctorate during recent years.

Historiography and Historical Writing

The years since World War II have been fruitful in terms of producing a variety of historical writing in education, psychology, and the social sciences. Certain of the references in this section deal with the methodology of historical research, while others are concerned primarily with the historical backgrounds of such areas as education, psychology, sociology, and philosophy.

Curti and his committee (73) arrived at a number of propositions relating to basic premises of inquiry, methodological precautions, desirable technics and principles, and relations with neighboring disciplines. Woody (87) outlined the conceptions and philosophies of history, as well as methods and technics of historical research, with illustrations and applications of special interest to workers in education.

Cone (24) emphasized that certain larger factors affect especially the disposition of written history, and also may influence rhetorical artifice. "These three major factors are purpose, content, and scope, all of which directly affect and sometimes determine the selection of facts, the organization, arrangement, shaping, proportioning, composing, and adapting the materials (disposition), and the manner of writing (style)."

Cohen (21), the logician, criticized sharply all monistic theories of historical change, but repudiated the skeptical view that, because no historical account can be complete, scientific history is impossible.

Wittels (85) maintained that the economic explanation of history leaves a gap which psychology has to fill:

> An explosive part is played in historical events by unconscious defense mechanisms against bisexuality, father or mother fixation, sadism, masochism, exhibitionism, and other instincts. The content of radicalism may suddenly swing to the opposite extreme: leftists might change to radical conservatives and vice versa, because of a blind inner urge. Revolutions, the origin of religions, cannot be explained by economic (materialistic) reasoning alone. Not only the "how" of historical developments is created by exceptional men but also the "what."

Garraghan's (34) metaphysical philosophy of historical interpretation covered the meaning of history, nature and classification of sources, criticism and appraisal of sources, and synthesis and exposition in presentation of the narrative (36). Collingwood (23) traced the philosophy or idea of history from Herodotus to the present. Einstein (29) analyzed the meaning of change as it affects history, especially as illustrated in the practices of dictators; he spoke of power as the instrument of change and of history as its record.

Other recent titles of books included in this area were: *The Study and Teaching of American History* (75), *Methodology of the Social Sciences* (53), *The Use of History* (66), *Work and History* (72), *The Greater Roman Historians* (57), *Protohistory* (89), *In Defense of Materialism* (65), and *This Thing Called History* (81).

Brennan (13) wrote from the standpoint of a Thomist, seeking to achieve in psychology a reconciliation between science and metaphysics. Dennis edited a book, *Readings in the History of Psychology* (26).

Barnes and others (6) discussed social origins, ways of group life, and other aspects of sociology from Comte to Sorokin, covering the important countries of the world from the ancient Near East to the present. The second edition of *The Development of Social Thought* (10) appeared.

Rugg (67), recognizing that the present disagreement among scholars stems from the conflict of three centuries between the philosophies of authority and of experience, took his stand with Peirce, James, Dewey, Veblen, Whitman, and O. W. Holmes, and analyzed the foundations of education in psychology, sociology, esthetics, and ethics. His historical treatment covered many aspects of cultural life in this country from 1890 to the present. Broad historical treatments of the backgrounds of education were: Brubacher's *A History of the Problems of Education* (14), Edwards and Richey's *The School in the American Social Order* (28), Good's *A History of Western Education* (43), Melvin's *Education: A History* (59), and Mulhern's *A History of Education* (63).

Russell (69) sought "to exhibit philosophy as an integral part of social and political life: not as the isolated speculations of remarkable individuals but as both an effect and a cause of the character of the various communities in which different systems flourished. This purpose demands more of an account of general history than is usually given by historians of philosophy." Other historical treatments of philosophy were by Miller (60), Fuller (33), and Gilson (36).

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CHAPTER II

Studies of Individuals

RUTH M. STRANG and DEBORA PANSEGROUW

IF IT is true that "wars begin in the minds of men," it is extremely important that we understand the dynamics of personality—why people behave as they do. Personality is still a vast domain in which much research is needed. During the three-year period covered by this issue, however, a number of significant books on personality have been written. Murphy's *Personality, a Biosocial Approach to Origins and Structure* (61) explores personality thru present research, not only in psychology but also in sociology, anthropology, and biology, and points the way to more significant research. Young likewise has a broad base for his study of *Personality and Problems of Adjustment* (98). Stagner has completely rewritten his *Psychology of Personality* (84), covering recent work in projective testing and supporting a point of view that emphasizes perception and the interior organization of experience. An important new anthology, *Personality in Nature, Society and Culture* (53), consisting of papers by thirty-seven authorities in the field, presents an orderly statement of our present knowledge of personality formation. The strictly experimental quantitative approach was taken by Eysenck in his *Dimensions of Personality* (32). Largely from researches carried on with 10,000 normal and neurotic subjects at a wartime mental hospital, Eysenck and his associates succeeded in factoring out and describing two main dimensions of personality, named, with reservations, "neuroticism" and "extraversion-introversion." Similar in its quantitative experimental emphasis is Cattell's *Description and Measurement of Personality* (18), in which he discussed the findings of published and unpublished studies and showed how clinical observation, rating of behavior, self-inventories, and objective tests have contributed to our understanding of the "factors, syndromes, and traits" of personality. Its emphasis is on methods of research. Entirely concerned with methodology is Rapaport, Gill, and Schafer's second volume on *Diagnostic Psychological Testing* (70).

Much of the research that would naturally be included in this chapter has been recently reviewed by Anderson and Embree in the REVIEW for April 1948 (Vol. XVIII, No. 2) and in several chapters of the REVIEW for February 1947 (Vol. XVII, No. 1) on *Psychological Tests and Their Uses.* The chapter by Havighurst, Kuhlen, and McGuire on "Personality Development" in the REVIEW for December 1947 (Vol. XVII, No. 5) likewise contains much of significance on studies of individuals.

Approaches to the Study of Individuals

Three important trends in approaches to the study of personality are: (a) the broadening of the developmental approach, (b) the focus on the dynamics of personality, and (c) the approach thru the study of interpersonal relations. Developmental studies of individuals have used a combination of technics and statistical methods. More precise instruments to use in quantitative experimental developmental studies are described in the second revised edition of Gesell and Amatruda's *Developmental Diagnosis* (38).

The increased use of projective technics, personal documents, and verbatim reports of nondirective interviews in research on personality is evidence of the dynamic emphasis. Instead of focusing attention exclusively on the child's overt behavior, the observer is concerned about the springs of behavior. According to Wolff (97), he should be guided by two major concepts: (a) that a child's behavior is an expression of his "search for self," and (b) that the child's view of the world is quite different from the adult's.

Since an individual's personality is often reflected in the behavior and attitudes of other persons toward him and his response to them, the study of interaction in groups and in different environments and cultures is an important approach to the study of individuals.

Technics for the Study of Personality

Because the description of personality is determined so largely by the instruments used, technics for research on personality are extremely important. For example, a concept of personality as a mosaic of separate traits and behavior is built by personality inventories and other instruments that collect only isolated details, whereas quite a different description of personality is obtained thru technics that reveal the inner world and motives of persons. Each of the major technics will be briefly reviewed.

New Uses of Psychometric Tests

Psychometric tests are being increasingly used in a more flexible way. The research worker sometimes modifies the directions of standardized tests in order to study aspects of personality not revealed by test scores. For example, by adapting the administration of standardized tests to poorly adjusted individuals more valid IQ ratings may be obtained than when the directions for the test are rigidly followed (47).

Qualitative analysis of intelligence test responses has been used to differentiate between mental defectives and normal pupils. Cruickshank (20) observed the reactions of children in these two groups to the most difficult arithmetic problem in the Binet test. The mental defectives were characterized by their lack of autocriticism, unwillingness to admit inability to solve the problem, and blind manipulation of the numbers. In another experiment (88) the defective individuals were found to give superior responses on eleven items and inferior on eighteen items of the Binet test.

Other verbal tasks have been used to study disorders of conceptual thinking (71). Only the normal adults were able to function at an abstract verbal level, and this ability differentiated them from children and from paretic and schizophrenic patients. Other evidence that psychometric tests can be used to study emotional adjustment was obtained by Despert and Pierce (25) in their study of the relationship between test results and the total records of preschool children. Psychometric tests are being increasingly employed to differentiate between normal and abnormal persons. Rabin (69) summarized research on the use of the Wechsler-Bellevue Scale for this purpose.

An example of the diagnostic use of tests designed for another purpose was described by Klein (51). The procedure was for each cadet to estimate his performance before and after each of the six psychomotor tasks. This modified level-of-aspiration technic indicated that "cadets who overestimate their performance are more likely to fail in flying training than those who underestimate their performance." The further extension of this type of study of test results has very definite possibilities for research.

Another development in the use of psychometric tests for studying individuals is the recognition of individual differences in the suitability of tests for different subjects. Vernon (91) found verbal intelligence tests very useful for testing high-grade persons such as officer candidates, but far less satisfactory for dull and poorly educated men.

Personality Inventories and Questionnaires

The rise and fall of personality inventories is indicated by the few references to the Bernreuter and the Bell inventories and many references to the *Minnesota Multiphasic Personality Inventory* (12, 56). Anyone planning to use personality questionnaires in a research study should read carefully Ellis' review (29) which presents evidence of the low validity of these instruments.

However, personality inventories have not been discarded for research purposes. Instead, they have been used for pattern analysis, i.e., the study of patterns of responses and personality profiles derived from them. For example, Gough (40) described a method of finding diagnostic patterns on the *Minnesota Multiphasic Personality Inventory*, and Meehl (58) has done significant work on profile analysis. The two main methods of interpreting profiles are the statistical and the intuitive, the latter being at present superior to the former. As regards the former, Du Mas (27) found the Chi-square method preferable when time is not a factor.

An attempt was made by Winthrop (96) to study personality integration by means of a paper-and-pencil test of attitude consistency. He found marked differences among college students in the consistency with which they responded to contradictory statements of attitudes. This inconsistency he attributed to "semantic blockage" and lack of a sense of logic and ability to see relationships.

The question as to whether signatures on questionnaires of a personal nature have a substantial influence on their validity has been somewhat differently answered by various investigators. Altho the effect of signing seems slight in the majority of cases, it may be important when serious personal problems are being studied (22, 35).

Jackson (48) compared paper-and-pencil tests, interviews, and ratings with respect to their effectiveness for evaluating personality. He found that paper-and-pencil tests and interviews were influenced least by "extraneous factors" such as school achievement and intelligence. Ratings were considerably influenced by these factors, more so in the case of teachers' ratings than in the case of ratings by parents.

Observation

As a method of studying personality, observation has become increasingly important (15). Howie (45) described how observation could be used more effectively in the classroom by selecting traits that can be observed under school conditions, knowing the subjects for at least a year, systematically focusing on one trait at a time, and making the comparison of pupils more explicit by sorting procedures. Newman (65) described a procedure for observing adolescents in informal groups, using a "composite" scale of behavior patterns and other forms of behavior-rating scales.

Sociometric Technics

During the last three years much has been learned about relationships of individuals in groups by means of the sociometric technic. Sociometry is the method most frequently used in research on group dynamics and the interaction within school and community groups.

The newer trend in sociometric study of individuals is to describe the personality of persons having different sociometric status, or "choice positions." Northway (66) reviewed the Toronto studies on this subject. Bonney (11) reported factors related to mutual friendships. Other investigators (54) have found that ninth-grade pupils who on the sociometric test were least accepted by their classmates, mentioned more personal problems on the Mooney *Problems Check List.*

Personal Documents

Not many significant developments in the use of personal documents for research purposes have been reported during this three-year period. Combs (19) analyzed the autobiographies and T.A.T. protocols of forty-six university students and found much overlap in the material obtained by the two instruments.

Many valuable insights may be obtained from personal documents such as "Letters from Jenny" (50) and "Children's Autobiographies" (68).

Expressive and Projective Technics

The Rorschach method and other projective technics have been thoroly reviewed by Hertz, Ellis, and Symonds in the February 1947 issue of the REVIEW and by Anderson in the April 1948 issue. Accordingly, references relating to research on the technics themselves will be omitted here and this chapter limited to trends in the use of projective technics in the study of individuals.

There has been an enormous interest in projective technics to the neglect of certain other methods of studying the individual. Projective test responses may be studied in a number of different ways. Clauses, sentences, paragraphs, or episodes may be analyzed and coded as in the standard procedure for the Rorschach and the T.A.T.; or a set of categories may be applied to the responses to a card or picture as a whole (37). An insightful synthesis may be made by clinical study of the total responses.

Projective methods are being applied to everyday situations in which the person can make a relatively free, extended, and personal response. (This free response is carefully recorded. It may be elaborated by searching questions as in "the inquiry," and projective methods of interpretation are then applied.) An example of this wider application of projective methods is Sims's description of "the essay examination as a projective technic" (81) and Munroe's "use of projective methods in group testing" (60).

Projective methods are being used increasingly with adolescents and adults. An example of this trend is the application of an adapted set of the Lowenthall "Little World" material, usually used with children, to 100 adults (10). In response to the invitation to do as they pleased with the materials, the majority of the adults represented everyday life as it appeared to them. An analysis of their responses gave personality pictures of the individuals and an understanding of certain aspects of life in our culture. Correspondence with personality patterns of the same subjects obtained from biographies was high.

Projective methods of administration and interpretation are being increasingly applied to standardized psychological tests. All psychological tests are projective insofar as they reveal the individual's personality structure and inner world. Various types of personality disorders are detected by studying, qualitatively as well as quantitatively, the successes and failures, the scatter pattern, and scores on subtests of an intelligence scale or other standardized test. For example, the Wechsler-Bellevue test has been used as a "nonprojective personality test" to reveal impairment of mental functions and its effect on personality (80). The use of psychological tests for this purpose is based on the assumption that mental illness manifests itself in a person's thought processes, as expressed in the test performance (70).

Among the developments in methods of studying individuals by means of the Rorschach are the graphic method proposed by Hilden (44), the inspection technic and use of diagnostic signs developed by Munroe (59) and by Buhler, Buhler, and Lefever (14), the multiple-choice group Rorschach which has not been generally satisfactory even as a screening device, and the supplementing of Rorschach responses by free associations that further aid in the qualitative interpretation (49).

During the three-year period covered by this review, the second volume of Beck's manual for the Rorschach test (6) has been published.

More has been learned about the applicability of the Rorschach to children as young as three years (36), the personality patterns of old persons (52), the study of personality in preliterate cultures (55), and the personality factors in reading disability (93).

During the war, quick technics of measurement and statistical treatment of data were developed. *Rorschach Standardization Studies* (14) are in this direction. They aim to standardize a list of diagnostic Rorschach signs that would simplify scoring and interpretation. Some of these short-cuts can be used in civilian measurement. They should be critically examined, however, to be sure that they do not lead to superficial or erroneous descriptions of personality. Nor should these short methods be substituted for a much more significant analysis and integration of subjects' total responses.

Hertz, Ellis, and Symonds, in a chapter on the Rorschach method and other projective technics in the February 1947 REVIEW, pointed out three dangerous trends: (a) oversimplification of administration, scoring, and interpretation; (b) modification of the method to allow use by untrained persons; and (c) use of group technics before adequate study of their effectiveness.

In a comparative study of motivations as revealed in Thematic Apperception stories and autobiography, Combs (19) found considerable agreement with respect to underlying drives indicated by the two methods. The T.A.T., however, revealed more desires relative to the past and future, and also more socially undesirable desires.

The projective technics, being based on material to which the subject has no ready-made responses, are less dependent on the culture than are tests having a large element of achievement. Accordingly, they are especially valuable for studying personality in different cultures. Henry (43) described the use of the T.A.T. with about one thousand Indian children in the study of culture-personality relations.

In giving the T.A.T. to six mental patients and a close relative of each, Rosenzweig and Isham (77) obtained complementary material that supported and extended the case history data and that emphasized areas of conflict between the patients and their intimate associates.

Paintings and drawings, analyzed as to content and form (line, color, use of space, organization) have revealed personality characteristics similar to those made thru a study of the same children at home and at school (1). The drawings may be free and spontaneous or made in response to certain directions. In one experiment (95) the personality sketches made on the basis of the drawings were recognized by the students' teachers in 103 out of 116 instances. In finger-painting, interpretation properly made gives clues as to the personality dynamics of the subjects and shows differences in age, sex, and background. The correspondence between observation and clinical diagnosis is reported to be high (62, 63).

A different use of drawing is to ask subjects to draw what they felt were the most important events of their lives. Here drawing was used as a means of communication in the same way that verbal responses to a given stimulus might be used (30).

Play technics, while used extensively for therapeutic purposes, also help to diagnose personality and show the dynamics of child behavior (3, 4). Differences between psychotic delinquent children and normally adjusted children with respect to relationships of children to father were revealed in a standardized projective doll play (5).

The Rosenzweig picture-association is a method of studying the reactions of children and adults to frustration (75, 76).

The incomplete sentence has been used for various purposes: as a screening device and as a method of measuring improvement in adjustment. It seems to reveal anxieties and hostilities better than ratings and reports (74, 78, 86, 87). It yields information on (a) conflict or unhealthy responses, (b) positive or healthy responses, and (c) neutral responses. Goodenough (39) presented the free association test as a technic of great value in giving "signs" that indicate personality structure.

Interview

As the interview has become more nondirective, its value for studying personality has increased. Sound-recorded interviews, in which the person tries to understand himself, supply important data for research on personality (21, 73). Thus far, however, the interview has been used far more extensively for counseling and psychotherapy than for research.

Case Study

In their evaluation of the case study as a research method Symonds and Ellis stated in the REVIEW for December 1945 that "the case study has been of increasing value to students of research in education, psychology, sociology, and anthropology; . . . progress has been made in the technics of gathering and treating case-study data for research purposes; and . . . case material has been employed in many significant investigations" (p. 352).

The case study, like the interview, has been used primarily for service rather than for research purposes. The bulk of published material consists of case histories and studies (16, 82). These case studies give a "realistic synthesis" of individuals. If more systematically collected, case studies can be used for research purposes. They have been used to study certain relationships such as that between symptoms of maladjustment and background factors (83) and differences between unselected students and students with emotional problems (57). The difficulty of interpreting a case study was highlighted by Elkin (28) who found wide disagreement on the part of thirty-nine persons who attempted to interpret the motives and adequacy of adjustment of the same case, and by Davis (23) who compared the value of the case study with data from mental tests for different purposes. He found the case study more important in clinical diagnosis and the tests in vocational guidance.

As in other technics, attempts have been made to make a quantitative analysis of case records as the basis for generalizations about clients (9). This approach is in opposition to the view of individual cases as unique.

New Methods of Diagnosing Personality

Many new methods mostly of the projective type for diagnosing different aspects of personality have been proposed but not sufficiently validated. Among these are (a) a new perceptual test (2) in which simple letter combinations are exposed for 0.5 seconds to determine certain features of personality such as speed, accuracy, consistency, cautiousness or venturesomeness, level of aspiration, and emotional disturbances of various types; (b) a picture interpretation personality test, similar in theory to the T.A.T. but dealing with different subjects such as the child in his various relationships (13); a verbal projective technic in which the subject responds to the question: "tell me three things that are impossible" (26); (d) a modification of the Sargent test, which consists of briefly described situations emphasizing the major conflict areas of the personality and followed by questions such as: What did he (she) do? Why? How did he (she) feel? (34); (e) the study of dreams as projective documents (42).

Individuals may be studied thru their responses to annoyances. Bennett (7) found differences between neurotics and those having no record of neurotic behavior with respect to their specific sensitivity to noise and their general sensitivity to stimuli reminding them of their personal inadequacy. The phenomenon of "autokinetic movement" has been shown to differentiate between various kinds of mental patients (94). Different individuals perceive, with high reliability, various patterns of movement when they look at a stationary pinpoint of light in an otherwise totally dark room.

New Combinations of Methods

Research using a combination of methods or a battery of tests is increasing. Many significant new developments are reported by the U. S. Office of Strategic Services in the significant report, *Assessment of Men* (90). New combinations of methods are being tried, as, for example, a T.A.T. type of test with the sociodrama (33) in which the feelings described in the picture story are acted out in the role-playing situation.

thus fusing diagnosis with therapy. Some of these methods have been combined to study the relationships among physical, mental, and motor characteristics, as, for example, the use of the sentence-completion test with psychogalvanic response (17).

In a camp situation a combination of observation, paper-and-pencil tests, and projective technics gave insight into the personality of individuals (31). The counselor's observation and his judgment recorded on the Canter questionnaire showed how the campers behaved in the group; the *Rogers Test of Personal Adjustment* gave information about their wishes and likes; the Rorschach and analyses of paintings gave insight into their personality structure.

Diagnostic Study of School Subjects

Diagnostic methods in school subjects have been summarized in the December 1945, April 1946, and February 1947 issues of the REVIEW; in yearbooks of the National Society for the Study of Education (64), and in Russell's short review on reading disabilities and mental health (79). The most extensive research in the field of reading is Robinson's report of her clinical study of thirty children (72). The analytical approach was represented by the description and classification of the major factors, and the synthetic approach by the reports of cases in which all the data obtained by a group of specialists were brought together. By discussing the diagnostic data on each child in a case conference, the most probable causes of the reading problems became clearer and a program of treatment was suggested. The major causes of failure in this study were found to be poor family interrelationships; visual anomalies; emotional problems; inadequate methods of teaching of reading in school; neurological, endocrine, auditory-acuity, and other physical difficulties; and speech and functional auditory factors.

In Gray's "Summary of Reading Investigations" (41) few new methods of studying reading difficulties and development were reported.

An indirect method of ascertaining reading maturity was described by Husband (46). He found that a preference for the precise, concentrated passages as against the loose, ambiguous selections in both poetry and prose was associated with high intelligence. From a battery of tests certain patterns of relationships seem to be characteristic of retarded readers, as, for example, with respect to associative learning and memory-span test findings (85).

The use of instructional tests is an important means of evaluating growth in critical thinking, ability to get the author's pattern of thought, and other broader phases of the language arts not usually included in standardized tests (67).

Very little has been done in self-diagnosis and the client-centered approach in dealing with difficulties in school subjects. The cases reported have had the service rather than research emphasis.

An important practical trend is the application of diagnostic methods to everyday school tasks, i.e., diagnosis while teaching and learning. Closely allied to this trend to make diagnosis an intrinsic part of instruction, is the use of informal instructional tests to collect valuable information about how children learn specific kinds of subjectmatter.

New Developments and Trends

Two main trends are discernible in the use of these technics for research purposes. One is the trend toward making the collection, interpretation, and treatment of the data more analytical and objective, more like the quantitative scores on standardized psychological tests. This tendency is shown by measurement of individuals' characteristics by means of more numerous and specific objective tests (24). The same trend is shown in the attempts to objectify, analyze, categorize, and quantify case data. It is also shown in the efforts to devise definite scoring methods for the Rorschach, T.A.T., and other projective technics.

A parallel trend is the insightful synthesis of comprehensive data—responses in projective technics, case study, and various types of tests and inventories. For example, the Office of Strategic Services (90) reported the successful use of observation of persons in a variety of situations unfamiliar to them. On the basis of three days' observation of each person, trained observers obtained an understanding of the dynamics of personality that stood the test of success on the job (90).

During the war, tests were used lavishly in appraising individuals' qualifications for certain jobs. This war need has paved the way for the study of personality by means of batteries of highly-specialized tests. Research in this direction is represented by the *Thurstone Tests of Primary Mental Abilities* (89) and the *Differential Aptitude Tests* by Bennett, Seashore, and Wesman (8).

Statistical methods of treating personal data obtained on Navy and Army personnel during the war have significant implications for present research, especially in the field of vocational selection (92).

Research might be facilitated by quicker methods of administering and scoring. Along this line are the attempts to adapt the Rorschach, the T.A.T., the Minnesota multiphasic inventory, and other instruments to group methods of administration and multiple-choice or other objective-type responses, and to quick methods of scoring. These efforts, however, have not yet been successful, and may be in the wrong direction, away from clinical interpretation of whole responses.

Perhaps the most important future development lies in the use of technics such as the projective technics, the sociodrama, and the nondirective interview—which have previously been used primarily for service purposes—for research in personality.

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CHAPTER III

Evaluation, Trend, and Survey Studies

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THIS chapter presents brief reviews of selected evaluation, trend, and survey studies for the period July 1945 to June 1948. Most of the studies represent applications in the more usual educational situations without the benefit of financial support from private foundations or agencies. The emphasis in the various appraisal technics reveals a growing interest in personal and social characteristics as well as the more intellectual factors. Some slight increase in follow-up types of studies is apparent.

Formulation and Definition of Objectives for Evaluation

An outstanding contribution to the field of evaluation, *The Measurement of Understanding* (67) contains lists of objectives stated in terms of behavior and specific illustrative evaluation technics for the fields of social studies, science, mathematics, language arts, fine arts, health, and physical education, home economics, agriculture, technical education, and industrial arts. Harris (44) discussed various problems in school appraisal, and Wrightstone (99) stressed evaluating primary school achievement in terms of multiple objectives thru the use of standardized and teacher-made tests and technics in areas like readiness, attitudes, interests, creative expression, and personal-social adaptability.

At the close of World War II, the Extension Services of the Land Grant Colleges and Universities, the United States Department of Agriculture cooperating, completed thirty-one years of existence as an educational agency to rural families. A committee (94) was appointed to review its work and define the scope of the Extension Service educational responsibilities as they can be foreseen for the coming years. Likewise a 4-H Club committee (93) reviewed the objectives of 4-H Club work for boys and girls, and reformulated these objectives as ten guideposts for 4-H Club work.

At the college level, studies of objectives and their evaluation were conducted. Dunkel (25) formulated a list of twenty main goals from papers written by students and teachers. Patterns of goals for individuals were obtained by having each student rank all goals by the method of paired comparisons. Marsh (62) asked a group of college students who had just completed their first course in psychology to indicate how important fifteen stated objectives were for them and how well they thought these objectives had been attained in the course. Only a fair degree of relationship existed between how important an objective was judged to be and how well it was attained in the course.

Construction and Refinement of Evaluation Technics

Greene, Findley, Couey, and Stanton (40) reported training the instructors at Air University, Maxwell Field, Alabama, in construction of evaluation instruments. The instructional staff cooperated with test specialists in planning, constructing, editing, analyzing, and interpreting the findings from tests, rating scales, and other evaluative instruments. Dexter (22) constructed a questionnaire for students' evaluation of a course of study. Sartain (80) devised a scale to measure student attitude toward the difficulty of a college course and applied the scale to various psychology courses to show differences between value, interest, and difficulty of these courses.

In studying the relative effectiveness of paper-and-pencil tests, interviews, and ratings for personality evaluation, using the *California Test of Personality* and the Woody *Student Inquiry Blank* as criteria, Jackson (52) concluded that each of the technics has differential values for predicting personality traits. Raths (72) discussed social accomplishment and the process of test construction as factors making for the validity of the *Social Acceptance Test.* Raths and Metcalf (73) reported a reliability of over .90 for *The Wishing Well*, an instrument for identifying needs of elementary school children. In a comparison of a written test on superstitions, with the (unobserved) behavior of a sample of fifty-one ninth-grade pupils, Zapf (100) obtained a correlation of .79±.03. A five-point scale check list of 200 items based on the ten imperative needs of youth as gathered by a committee of the National Association of Secondary-School Principals was presented for further refinement by French and Ransom (34).

Evaluation Studies

Elementary and Secondary School Levels. An increasing interest in sociometric studies is reflected in the literature. Blanchard (5) summarized eighteen studies made between 1902 and 1946. He concluded that the studies were mainly at the elementary level; the technic most frequently employed was the questionnaire; and the factors which influenced choice of friends were work groups, play groups, social groups, chronological age, mental age and IQ, home background, personality traits, development, and social adaptability. Austin and Thompson (3) studied children's friendship patterns and found that personality characteristics, geographical propinquity, and similarity of interests accounted for status of and changes in friendships. An analysis of social relationships in a war-boom community by Morgan (65) thru the use of questionnaire and a sociometric test revealed the importance of father's income and level of school achievement. Cook's experimental sociographic study (13) showed how the teacher, familiar with classroom friendship structures, can modify and change such structures in the direction of increased group interaction. Horns and Watson (50) showed that for fourth- to sixth-grade children in an upper-class private school, gentile children were more clannish than Jewish children. An interracial study of social acceptance by Raths and Schweichart (74) showed a generally higher acceptance of boys and girls along color lines (white and Negro), altho many white boys and girls showed a high acceptance of colored members of their own sex.

Gates (36) used a teacher rating scale, employer ratings, disciplinary records, participation in civic enterprises, participation in school, community and church activities, teacher observation, and peer ratings in an evaluation of civic competence of 489 high-school seniors.

Olson (69) reported an intensive study of a third grade in the University of Michigan laboratory school. Pupils were studied in an attempt to improve the quality of social relations in the group. Teachers, a pediatrician, a psychometrician, and a biologist collaborated to analyze the psychobiological characteristics of the group. Family and community relations were studied. Sociometric tests were made at the beginning of the study and again after six months of recommended treatment of the group involving changes in teacher technics and suggestions resulting from parent conferences. The follow-up study six months later gave the teachers' subjective estimate of improved social relations, but the sociometric tests failed to reveal significant changes. The conclusion was that children's social relations in a classroom have deep roots in community and family living as well as in the physical, mental, and emotional differences among the children.

Gilbert and Wrightstone reported (37) on the first systematic evaluation of camping as part of a public elementary-school program. Using matched groups of fifth- and seventh-grade pupils and a battery of tests, the investigators concluded that camping was a valuable aid in promoting democratic education. The authors recommended increased teacher education along recreational lines and an extension of camping experiences and their evaluation.

Rothney and Hansen (77) evaluated a broadcast series on the Wisconsin School of the Air. They found, primarily by questionnaire, that pupils liked the series, identified the program with their own local towns, and showed no evidence of bias on choosing favorite characters in the program. In a sub-study of the intercultural attitudes of a control (nonprogram listeners) and experimental group (program listeners), some statistically significant differences in favor of the experimental group, not necessarily attributed to the influence of the radio series, were found.

College Level. Various studies have compared achievement of veterans and nonveterans in college. Epler (27), Clark (9), Thompson and Flesher (86), Tibbitts and Hunter (87), Stewart and Davis (84) found generally that veterans make as good or better grades than nonveterans. Clark (9) interpreted the data as indicating that veterans were better motivated and worked harder to succeed in their classes than nonveterans. Flesher (29) made an intensive study of seventy-six women who obtained their undergraduate degrees in three years or less. Each accelerate was paired with another student of the same age and ability at entrance. The accelerates had a superior average grade but were not superior in extracurriculum activities. Assum and Levy (2) compared the academic ability and achievement of two equated groups of seventy-one students, one group of which had applied at the Counseling Center of the University of Chicago for help on personal problems. On the college comprehensive examination, the less well-adjusted group gave evidence of poor academic achievement but had equal achievement on the college reading and writing ability tests. Toven (89) compared a counseling program at the college level for a group of 188 students who were systematically counseled for four years and a control group of 188 students who were not counseled. The study indicated that the counseled students had fewer scholastic difficulties, completed more point credits, and better realized their aims in attending college. Hewitt (46) reported guidance thru self-appraisal in a program in which use was made of (a) technical information and personality inventory tests taken by the students; (b) reports from teachers; (c) student autobiography; and (d) the counselor's summary. Griffiths (41) studied the relationship between scholastic achievement and personality adjustment of men college students. He concluded that men with brilliant scholastic records are not better emotionally adjusted than those with lower academic achievement and that unsatisfactory personality scores are not significantly correlated with unsatisfactory grades. Kilby (56) reported that students who received remedial reading instruction in college earned significantly higher final grade averages than did those in an untrained control group. Bloom (6) studied the implications of problem-solving difficulties for instruction and remediation in the College of the University of Chicago. Poorer students showed greater difficulty in understanding the nature of problems, probably as a result of reading disabilities. They exhibited attitudes of a lack of confidence and were unable often to relate a problem to information already possessed. Attempts to change problem-solving methods on an experimental basis have been successful and have resulted in improved examination marks. Wells (97) reported the psychometric work of the Grant Study with well-adjusted Harvard undergraduates. The data from psychological tests were integrated with data from general medicine, physiology, anthropometry, and psychiatry to evaluate adjustment to higher education. Reed (75) compared two colleges, K and M, on the *Michigan Vocabulary Profile Test*. Only 8 percent of the K students equaled or exceeded the median for M students. The study showed M students who had a higher average intelligence test score had read more books and more and better magazines.

Extension Education. In extension education, which is informal out-of-school education, evaluation studies have been conducted to obtain research findings on organizing rural adults and young people for informal teaching; their needs, interests, and social situations; planning educational programs; effectiveness of methods of teaching; the use of volunteer leadership; and measurements of results in terms of the objectives of teaching. The conduct of these studies is based on the proposition that objective data can be obtained on which to formulate administrative policy and modify teaching procedures.

Studies of the use of radio as a teaching method have received considerable attention in recent years. Crile (15) studied the extension radio program in Ward County, North Dakota. She found that farm families were reached over the radio who were not otherwise participating in extension programs. Listeners acted upon the information they received about farm and home practices. In Wisconsin three combinations of extension teaching methods were evaluated, radio and leaflet; radio, local leader and leaflet; and local leader and leaflet (20). Radio instruction was used effectively in Massachusetts to reinforce the teaching of homemakers by local leaders on making coats, suits, dresses, and other garments (71). In New York State also, the effectiveness of the radio in teaching a technical subject (dress making) thru a long series of lessons was tested (83). The listeners adopted many new sewing practices. In Minnesota, farm people prefer the interview type of radio program in extension education, according to Hanson's (43) study of listening habits. Most farm families have radios. The extension radio programs reach farm families not otherwise participating in extension activities. The findings of studies of farm and home radio programs were summarized by Crile (21) for administrative and program-planning use. A number of other studies of extension teaching by radio are now in progress.

The use of printed materials as a method is widely used in extension teaching and has been receiving attention in extension studies. Thru personal interviews with 216 farm families, Arbour and Mason (1) found that a monthly guide of things to do on the farm and in the home in Louisiana was used by those who received it. The need for simplifying the readability of Extension Service publications resulted from the study. Clark and Mason (10) found that a monthly leaflet on homemaking and extension news distributed to rural homemakers in Connecticut was widely read with more than half using the information in the leaflet. In a study of bulletin readership in New York, Ward (95) found the bulletins widely used, read, and accepted but found that more emphasis needed to be placed on pictures, simpler presentation, and shorter publications.

Burleson (7) in Louisiana analyzed 351 of the mimeographed letters and announcements which county extension agents send to farmers and homemakers on timely farm and home practices. He found the language too difficult and concluded that the agents rate higher in their knowledge of subjectmatter than in their skill to impart it thru letters. County extension agents in Kansas furnish local editors with nearly half of the farm news appearing in local papers. Hilgendorf (47) found that the local editors preferred separate news stories rather than farm columns. They felt the people would read and get more out of farm news stories if they were adapted to the local situation.

Cowing (14) has found thru the analysis of hundreds of written materials for farmers and homemakers that the reading difficulty level of the materials was too high for good comprehension. They are being simplified by using easier words, shorter sentences, and more personal references.

The degree of organization for home demonstration teaching with rural homemakers varies considerably over the country and even within states. In Massachusetts, Billings and Collings (4) found that communities having an advisory council member and a community committee had more successful programs than communities having a less complete organization. In the former, local leaders tended to continue longer in service, were better acquainted with their functions, had a clearer understanding of the scope of the Extension Service program, participated more in program planning and were more confident in their ability to make decisions on home problems.

Some Extension Service studies were devoted to evaluating the results of extension teaching in a county or over a state. Frutchey and Wing (35), thru a geographical sampling of over 200 farms, interviewed farmers and homemakers in Windham County, Connecticut. They found that more farmers with large enterprises adopted recommended practices than farmers whose farming activities were part-time or a sideline. They concluded that when the economic stake is high the adoption of recommended farming practices is higher.

In Vermont an independent agency was asked to evaluate the work of the Extension Service thru personal interviews with a carefully selected sample of farm families. The results are given in two publications (90) (91). The study covered sources that farmers and homemakers use in getting information, farm and home practice changes, and attitudes toward extension teaching.

A cross-section sample of 212 farm families was interviewed in Pontotoc County, Mississippi (64). It was found that the use of more than one teaching method increased the adoption of practices and that practices emphasized over a long period of time were more widely adopted.

A factor in increasing 4-H Club membership for informal teaching of boys and girls, is holding the membership of the older members. A cooperative study (53) in the New England states dealt with the characteristics of 4-H Club members thruout their high-school careers as well as with the characteristics of their clubs and local leaders.

Another cooperative study (59) brought out factors influential in getting parents' cooperation in 4-H Club work for their boys and girls. The researchers concluded that informed and invited people are interested people, and interested people are cooperative people.

Trend Studies

An excellent summary of trends in research, measurement, and evaluation in the past fifty years, including extensive bibliographical references, was written by Scates (81). Sabrosky (79) analyzed the annual reports of the states for 1946 and prepared statistical summaries of 4-H Club work on enrolment, number and size of clubs, age of members, length of membership, reenrolment, completion of the work, local leadership, and time county extension agents devote to 4-H Club boys and girls. Grandy (39) made a similar analysis for the State of Colorado covering the twenty-year period 1926-46. Sabrosky (78) also analyzed the annual reports of the states for 1946 and prepared statistical summaries for home demonstration teaching with rural homemakers.

Follow-up Studies

Franzén (32) summarized the responses to an opinionnaire of those who participated in the Cooperative Study of Secondary-School Standards. He found that revisions were needed especially in the sections dealing with outcomes, instructions, and teacher evaluation. An analysis (33) of the responses of 532 administrators whose schools were evaluated in the years 1940-1947, showed the need for improving various procedures.

At the college level, two follow-up studies have been reported. Knox (57) reported a sampling of eight Harvard graduating classes, distributed over the period 1880 to 1925. He found that graduation with honors was significantly related to prominence as determined by inclusion in *Who's Who in America*. A combination of scholastic class and outstanding extra-curriculum achievement supplied the best basis for predicting future success. In a follow-up study Jones (54) compared certain measures of honesty at early adolescence with honesty in adulthood. A coefficient of contingency of .37 was obtained between honesty as measured in early adolescence and adulthood. These results suggest that honesty depends upon progressive organization of inner and overt behavior and that such organization is usually well under way in late childhood or early adolescence.

Holcomb (49) made a follow-up study of 151 county extension agents on the job in Iowa. The agents found their subjectmatter training in college very helpful to them in their job of extension teaching but felt they had had insufficient preservice training in extension teaching methods, extension administration and organization, organization and teaching in 4-H Club work, adult education, program planning, office management and personnel, technical journalism, and evaluation of extension programs. Practically all of the agents favored induction training in these subjects for beginning workers.

Surveys

There were a variety of local, state, and national surveys in the literature of this three-year period. House and Thompson (51) made a limited survey of the constitutional growth of a small sample of seventh-grade Appalachian children and found various deficiencies affecting child behavior. Hawk (45) surveyed the speech needs of 1200 elementary-school children and found seventy students who needed special attention.

Administrative surveys included a questionnaire study (28) made by the U. S. Office of Education on the growing professional status of the public-high-school principal. Woody (98) inventoried 635 Michigan school administrators on the current problems or issues which they were facing in the state. Otto (70) found practices in the use of achievement tests, guidance in program making, departmental instruction, promotion practices, and library services in 286 public elementary schools and forty-six campus demonstration schools to be very similar. A questionnaire study (66) by Nannini showed that small town New York State school administrators consider housing, recreation, and education the main community problems; labor, inflation, government controls, housing, and education the main national problems; and atomic energy, feeding starving people, and United Nations the main international problems. Duckworth studied (24) the report forms of transfer students and found a serious lack of uniformity in grading systems. Flesher surveyed the elementary-school buildings (30) and secondary-school buildings (31) in twelve Ohio cities. He found inadequacies for both levels, tho the secondary-school buildings were newer and relatively more adequate. Butterworth and Gragg (8) reviewed an extensive list of school surveys conducted from June 1943 to June 1946.

Remmers and Davenport (76) presented data collected from the Purdue Opinion Poll for Young People showing how over 6000 high-school youngsters from thirteen states felt about such things as being a teacher, liking school, student government, work experiences, field trips, and teacher salaries.

Haas (42) received 415 replies to a questionnaire mailed to the 461 Wisconsin public secondary schools. He found that the schools allotted an "adequate" proportion of the curriculum to social studies, altho the titles of course contents followed traditional patterns. Also, he reported that a large percent of the small high-school social studies teachers were inadequately prepared.

McNelly (60) surveyed the county agricultural agent staff that was on the job in December 1947. Their average length of tenure was eight years. He also determined what they liked about their work and what they did not like.

A subcommittee (85) made a survey of working conditions of extension personnel to determine a basis for making recommendations on the improvement of working conditions and reducing turnover of personnel.

Collings (12) made a comprehensive nationwide analysis of how the home demonstration agents use their time. One hundred seventy-seven agents selected proportionately over the country and at random in a region, kept a daily record by five-minute periods for one week in the winter and one week in the summer of their activities making 2422 days of extension activities for analysis. She found that the agents spent one-fourth of their time teaching and that they worked an average of 51.5 hours a week including some Saturdays and Sundays.

Thru a survey of 666 farmers in Alabama, Leigh (58) found that the average Alabama farmer reported using twenty-three ideas about improved farming practices which he received thru several means of communication. The number of ideas the farmers used increased consistently with the amount of education they had and the size of farm. Sixty-five percent of the farmers reported getting good farming ideas from children who brought them home from school.

A nationwide radio survey (92) of attitudes of farm and small town people was made thru a stratified random sample of 2535 households in 116 counties where 4293 interviews were made. Information was also obtained on program preferences.

Social relationships studies have been made to determine the organizations in a community and how they can function in channeling extension information to the people. Hoffer (48) found that the farmers of Eaton County, Michigan received useful information about farming from many sources. The neighborhood group and the rural school district were used very often to develop extension work. According to Miller and Beagle (63) school districts were a leading unity factor in social organization in Livingston County, Michigan. The religious factor was next in importance. Niederfrank (68) studied the coordination of agencies in carrying on an effective educational program in health and nutrition in a parish in Louisiana.

Studies were made to determine needs, interests, and abilities as a basis for program planning. Handicraft and rural art activities (19) (26) were determined thru a nationwide survey including Hawaii and Puerto Rico. Many studies of local volunteer leadership have been made in the past because of the importance of the local leader in conducting extension work. The findings of these studies were summarized by Crile (16) for administrative use. Crile also prepared a bibliography (18) of extension studies and a review (17) of extension studies for 1946-47 which is a valuable source.

Frequency Studies

A review of recent research in vocabulary development was prepared by Seegers (82) who gave a comprehensive summary of studies reported in recent years. In more specialized studies Cobb (11) compared the vocabularies of the *Basic Vocabulary of Business Letters* with the *Gregg Shorthand Dictionary* and pointed out the similarities and differences between them. Tiremen (88) conducted a study which he felt established definitely that a large percent of the error made by native Spanish-speaking children in recognizing English words in isolation was caused by failure to pronounce correctly the elements of the words. In a study of slang vocabulary in a large school, Kasser (55) analyzed changes in slang vocabulary thru comparison with the results of a similar survey conducted eleven years before. Most slang words originated with the high-school group and spread to younger children.

A vocabulary analysis of twenty pre-primers, published since 1937 and representing eleven different series, showed that recent pre-primers have lower different-word count than earlier material and that there is an increasing similarity of vocabulary in the different levels (23). Malter (61) analyzed eight available studies dealing with children's preferences for illustrative materials and found that children (a) prefer colored illustrations, (b) have a wide variety of interests in subjectmatter, (c) do not like silhouettes, and (d) have preferences subject to change. Applying the Dale-Chall formula for reading difficulty, Guckenheimer (38) found in an analysis of thirty-six pamphlets on international affairs, that 75 percent of the material is at or above the college level in difficulty. A validity of .86, based on a correlation between the composite rating of seven judges and the formula, was reported. In an analysis of the distribution of emphasis in ten physics tests and twelve physics textbooks, Weaver (96) found that the textual contents differed considerably and that the tests differed in emphasis of material and types of test items.

Needed Research

The need for more rigorous research on the formulation and definition of major objectives of education is apparent. Present research is more opportunistic than systematic and comprehensive. The emphasis on informal, teacher-made evaluation technics represents a desirable trend, but research and development of more formal and comprehensive technics have progressed very slowly in recent years. Rationale and procedures in evaluative studies should be studied to establish more definitive criteria and principles. In surveys, trend studies, and frequency studies, a critical appraisal of procedures, criteria, and applications should be undertaken by one or more investigators to indicate improved designs and methods for these types of research studies.

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CHAPTER IV

Research Methods and Designs

JOSEPH LEV

REFERENCES included and reviewed in this chapter were selected because they contain a discussion or illustration of some aspect of experimental design, or application of such design.

Validity of Conclusions Based on Experiments

An experiment in educational research commonly involves selection of a group of individuals and the application of some experimental procedure to these individuals, in order to obtain conclusions which are applicable to a population of which the subjects in the study are a sample. For such extension of reasoning or "induction" to be valid, it is necessary to eliminate the various possibilities of bias in the experiment. Much attention has been given in educational research to the elimination of bias in the experimental procedure. In particular, care is taken to eliminate bias on the part of the experimenter by use of objective measures. Consideration is also given to making the experimental procedure fit the situation to which the experiment applies. Less attention has been given to the possibility of bias due to the selection of individuals who are the subjects of the experiment. Clearly, the subjects of the experiment must constitute a representative sample of the population, to which the conclusions of the experiment are to be generalized. Frequently, the logic of induction is accorded recognition only at the end of the experiment when tests of significance are applied but such tests are not valid if the sample is biased. Criticism of this aspect of experimental design was voiced by Walker (49), who noted that use has not been made of available knowledge of sampling theory.

A detailed analysis of sampling bias in several psychological studies appeared in two papers by Marks. In the first of these papers, Marks (32) questioned the validity of generalization from two psychological studies because of sampling bias. It is sufficient to review his comments on one of these studies. The responses of a group of psychology students in Dartmouth to a questionnaire on race prejudice showed that such prejudice was related to the education of their parents. Since the students were all from the same college, it is possible that selective factors operating in their admission to the college provided a biased sample in relation to the total population of America, or even to some more restricted population. By means of hypothetical data, Marks showed that selective choice from a population, in which the education of parents is unrelated to racial prejudice of children, might have resulted in a sample in which a marked relationship between the factors exists. Unless random selection is used, there can be no assurance of the elimination of bias in the sample.

In a second study Marks (33) reviewed the sampling used in the revision of the Stanford-Binet scale, which was of the type known as a cluster sampling, since subjects were obtained in groups from a number of communities. Marks pointed out the overemphasis given to a few communities in the sampling. Because of the similarity among individuals within a group, there is a possibility of intraclass correlation which influences statistical calculations. Marks suggested that greater validity might have been achieved by sampling more communities with fewer cases in each community. He also gave formulas appropriate for calculation of standard errors in cluster sampling.

The importance of relating the design of experiments to the logic of induction has been especially emphasized by Fisher (17). Altho Fisher dealt mainly with agricultural experiments, the logic of his argument is universally applicable. In an experimental procedure it is often necessary to take into account the operation of variables other than the ones with which the experiment is concerned. Thus, in a comparison of teaching methods, it is often necessary to consider the variation of intelligence among pupils, and the differences of teaching ability among teachers. In the simplest design this variation can be provided for by random sampling from the total population. It is often possible, however, to assure a more satisfactory sample by sampling randomly at various levels of the variables which disturb the experiment. Thus, in comparing teaching methods, it may be desirable to sample separately from boys and girls. Fisher pointed out that such a modification of experimental design called for corresponding modification in the logic of statistical inference. Since the differences between boys and girls have been excluded from the process of randomization, these differences must also be excluded from the calculation of the standard errors used to judge the statistical significance of the comparisons made in the experiment. By the use of analysis of variance it is possible to subdivide the total variability in the data into components which are due to the operation of known variables entering into the experiment, and other components which are due to random variation and are used in tests of significance. Beginning with a simple psycho-physical experiment, Fisher described a number of experimental designs and their related tests of significance. Methods of calculation appropriate to these designs were given by Engelhart (16) and by Snedecor (40).

Comparison of Groups When Individuals Are Classified into Categories

Frequently, research studies are concerned with individuals who may be classified as belonging to one or another of several discrete categories, such as sex or school grade. In such studies the observations are classified into the several categories and the frequencies in the categories are determined. The analysis then proceeds in one of two directions: (a) the observed frequencies are compared with expected frequencies based on theoretical considerations, or (b) the observed frequencies in several samples are compared with each other to determine whether they represent populations which have the same distribution.

A study using a theoretical distribution is that of Malter (30), who rated children on a test of ability to read cross-section diagrams. A theoretical distribution was constructed on the assumption that all responses were guesses, a like distribution was made up from the observations, and the two distributions were compared.

Two groups were compared in a study by Dolger and Ginandes (14). A group of children in a private school and a group of the same number in a public school were asked to offer solutions to a disciplinary situation told to them as a story. Their solutions were then classified as *constructive* or *nonconstructive*. The authors found a larger percent of constructive solutions among the private school children than among those in the public school. Some comment on the sampling may be of interest in this connection. It must be assumed that the conclusions based on the data were meant to be generalized to a population extending beyond the children in these schools. Since the sampling is limited to only two schools, all the numerous characteristics which differentiate the children of one school from those of the other specialize the populations to which generalization may be made to an unknown extent.

A more complex classification was used by Doane (13) in a study of professional curriculum requirements for high-school teaching. Colleges offering teacher-training courses were classified into three categories composing the three populations in the study. Samples from the three populations were then compared on the basis of proportions offering specific education courses. Chi-square tests of significance were calculated.

Comparison of Two Groups on Measurable Traits

Two comparisons are made: (a) the responses of two groups to the same set of stimuli (an intelligence test, for example) or (b) the responses of a given group of individuals to two sets of stimuli. In the first instance, random samples are drawn from the two populations and the groups are compared on some statistical measure, usually the mean. In the second instance, two different samples from the given population may be used, or the two sets of stimuli may be applied to the same sample.

Several studies comparing two populations of individuals appeared in the literature. Heisler (19) compared children who read comic books with children who did not read such books, on intelligence, personality and socio-economic status. Hobson (21) compared boys and girls on primary mental traits. Leeds and Cook (28) used two groups of teachers, one superior and one inferior, to validate items on a scale for determining attitudes of teachers toward pupils.

An example of a study, in which the responses to two sets of stimuli were compared by use of a single sample, is a study by Malter (31). The children were asked to read a diagram of a production process, both with and without the use of certain guide lines and arrows. The children were then tested on their comprehension of what appeared in the diagram under both sets of circumstances, and the mean scores of their responses were compared.

Von Eschen (46) used two designs to study the effect of supervision on teaching efficiency. In the first design, two different groups of students were selected, one to be an experimental group, and one a control group. The teachers of the experimental group were subjected to a prescribed form of supervision, whereas those of the control group were not so supervised. Mean pupil gains in achievement of the two groups were compared. In the second design, the control group of the first experiment became an experimental group the following year. Mean gains of the group for the two years were compared.

In a more complex study Gold (18) compared responses of students to various methods of teaching dental health knowledge. Two similar groups of students were chosen for the principal part of the study, which was to compare the effect of intensive training in dental health with only incidental training in the subject. From each of the principal groups a subgroup was chosen for training in a manner differing slightly from the main group. In the analysis, groups were compared in pairs, the two main groups with each other, and each main group with the subgroup drawn from it, three comparisons in all. Since four methods of instruction were used, an analysis of variance comparing all four methods at once would seem appropriate. Such an analysis would yield a sensitive test for all comparisons, and would make possible an investigation of the relationship between length of instruction and improvement in dental care.

Comparison of Several Groups on Measurable Traits

The patterns of experimental design considered in the foregoing section on two group comparisons may be extended to the simultaneous comparison of several groups. As in the former situation, group comparisons are made: (a) the responses of several samples of individuals to the same set of stimuli, or (b) the responses of a given sample to several sets of stimuli. The statistical method applicable to these designs is the analysis of variance.

A study by Blum (3) illustrates the comparison of responses of several populations to the same stimuli. Students preparing for five professions were compared on a number of personality traits. Analysis of variance was used to test the variability among the means of groups. As is customary in such studies, comparisons were made on each trait separately, altho methods for simultaneous comparison on several traits are available.

A study by Baldwin (1) illustrates a comparison of responses of the same individuals to differing stimuli. The *Fels Parent Behavior Scales* were given to a group of mothers during the periods of pre-pregnancy, pregnancy, and post-pregnancy. The hypothesis that the means of the scores for the three periods were equal was tested by analysis of variance. A test of the linearity of the means was also made.

Experiments in Randomized Blocks

In order that the conclusions of an experiment comparing several procedures may be generalized to a fairly extensive population, it is frequently necessary to sample individuals in several environments; for example, schools, communities, and grades. All procedures must then be tried in each environment, for, if some procedures are tried in one environment and others in another, it will not be possible to determine whether resulting mean differences are attributable to procedural or to environmental effects. Furthermore, it is necessary to take into account differences among individuals within a given environment. The last is achieved by assigning individuals within an environment to the various procedures in a random manner. The resulting design may be called a randomized-block design, because of its parallel to agricultural experimentation, in which randomization is performed within blocks of land.

This design is well described by Burt and Lewis (7). Twenty backward readers were selected randomly from each of five schools. The children from each school were divided randomly into four equal groups, each group to be taught reading by one of four methods of instruction. At the end of the period of instruction the gain of each pupil was determined. Using the gains as scores, an analysis of variance was made, yielding mean squares due to methods of instruction, schools, method-school interaction, and variation within the twenty subgroups. The authors used the variance within subgroups as the error variance to test the significance of the differences among method means. This calculation is questionable. It is valid if the conclusions are to apply only to the five schools used in the experiment. If, however, the conclusions are to be generalized to some population of schools going beyond these five schools the variance due to interaction should have been the error variance to test the differences among methods.

Bollinger's (4) study of the impact of teachers on pupils provides an illustration of an investigation carried on in several environments without elimination of bias due to environmental differences. Certain social attitudes and aspects of social adjustment of teachers and students in the high schools of three small communities were investigated. Bollinger found that in one of these communities both teachers and students had lower scores than the corresponding groups in the remaining two communities. The differences among the scores of pupils in the three communities were then ascribed to the *impact* of the teachers. Because of the design of the experiment, this conclusion has doubtful validity. Both teacher and pupil differences may be due to community differences. The last interpretation is supported by the results of a portion of the study in which the gain of pupils in social adjustment was studied in relation to the adjustment of teachers within a given community. Here a negative relationship was found, so that the pupils having better adjusted teachers gained somewhat less in social adjustment than pupils having teachers rated lower in social adjustment.

The Latin Square

The randomized-block design makes possible the consideration of a source of variation in addition to the variation among the procedures being studied. It is frequently desirable to consider two or more sources of variation in addition to the basic variation among procedures. A device, which provides a method for taking into account two such sources of variation, is the Latin square. This design is described by Fisher (17) and by Snedecor (40), and has been referred to in previous reviews published in this series.

Without using the terminology commonly associated with the Latin square, Wilson (50) used this design to study the effect of length of reading material on comprehension. Essays of 300, 600, and 1200 words were prepared on each of the three topics, "Paper Today," "Paper Industry," and "History of Paper." Each of three groups of children was then asked to read essays of all three lengths, but each length associated with a different topic. After each passage was read, a comprehension score was obtained for each student. The Latin square appears as follows:

	Paper Today	Paper Industry	History of Paper
Group I	300 words	600 words	1200 words
Group II	600 words	1200 words	300 words
Group III	1200 words	300 words	600 words

The value of this design is that each of the three lengths was tested on all students, so that the variability among groups was eliminated. In addition, each length was tested on three topics, so that the bias of a particular topic was eliminated. The author failed, however, to utilize these values in the analysis of the data, since she made all comparisons by using differences of means in the nine cells. The results did not, therefore, appear as conclusive as they might if the appropriate analysis of variance had been used. Thus, in one of the topics, "Paper Today," the 1200-word essay resulted in little better comprehension than the 600-word essay, but further analysis shows that the longer essay was read by the group which was decidedly the poorest of the three. When analysis of variance is used, the variation among the means of the three essay lengths is very significant. A supplementary analysis indicated a linear relationship between essay length and comprehension.

Factorial Designs

An important aspect of educational research is the determination of factors which are related to individual differences. A factor is here understood to mean a method of differentiating individuals by classifying them in groups. Examples of factors are sex, national origin, and grade placement. Individuals in a sample may be classified in accordance with several factors simultaneously. Factorial studies usually proceed by obtaining a common measure for all individuals in a sample, classifying individuals on the basis of each of several factors, and comparing the means of groups within each factor separately. These studies neglect the overlap of factors, since several factors operate simultaneously to distinguish some individuals from others. This "interaction" of factors may indeed be the most interesting aspect of the study. The problem is discussed in (17: Chapter VI) and in (24).

Several examples of factorial studies follow: Smith (39) obtained scores on the *Bell Adjustment Inventory* for a group of students, and then compared means of groups in accordance with several factors, such as participation or nonparticipation in athletics, and membership or nonmembership in fraternities. Stright (42) considered similar factors in relation to scholarship. Both authors found significant relationships between the factors in question and the criteria. Since the authors neglected to study interactions, certain questions remain unanswered.

Cheydleur (10) examined the relation of several factors to success in college teaching. The factors were examined separately and no account was taken of interactions. The need for examining interactions is illustrated clearly by the two factors: (a) having professorial rank, and (b) not doing graduate work. Both of these were related to good teaching, and surely interact.

Brownell (5), who investigated two factors related to teaching subtraction, did consider interactions. One factor consists of two methods of teaching borrowing, and the other of teaching either method mechanically or by rationalizing the procedure. The analysis of data dealt with the subjects as four groups, distinguished by both the method of subtraction and the method of instruction. Thus, the analysis may be said to have dealt only with interactions, and to have neglected main effects. Comparisons were made by using differences of means between all possible pairs of groups. It is worth while noting that the methods of analysis of variance would have provided information regarding both main effects and interactions with a more sensitive test of each. The value of investigating interactions is further emphasized by Brownell (6: p. 111) in his critical comments on a later study of the same problem.

Schroeder (37) investigated the teaching of archery using three groups of students all of whom received six lessons in the skill. Three ranges of thirty, forty, and fifty yards were used, all students shooting at all three ranges at each lesson in varying order for different groups and different days. The experimental design permitted an analysis of the following four factors and their interactions: (a) groups, (b) test halves (the first three lessons against the last three), (c) order of shooting at a given range within a given lesson, and (d) length of range. Information was obtained of main effects and first, second, and third order interactions by use of analysis of variance.

The "Split-Plot" Design

This design owes its title to a type of agricultural experiment in which several procedures are compared in a set of plots. In addition to comparing one plot with another, the plots are divided into two or more portions which are treated differently, so that intraplot comparisons can be made. There are then, in fact, two parallel experiments with different estimates of error (40: p. 309).

The split-plot design was used by Vergara (45) in a study comparing the comprehension of poetry in oral presentation with its comprehension when read silently. Sixteen poems of four types and two groups of subjects were selected. Each group read eight of the poems silently and listened to an oral presentation of the remaining eight. Thus, each poem had both an oral and silent presentation and, correspondingly, two scores. Two types of comparisons were then possible. Using the sum of the oral and silent scores for each poem it was possible to compare the mean scores of the four types of poem. Using the differences between oral and silent scores it was possible to compare oral with the silent presentation. The two comparisons used different estimates of error.

Use of Concomitant Measures in Group Comparisons

In the previous sections of this chapter experimental designs were considered in which all subjects are scored on a measurable trait and are then grouped into several categorical classes in accordance with one or more criteria of classification. These criteria of classification were considered as sources of variation in the data. It is often necessary to consider sources of variation which are based on measurable traits rather than categorical classes. Thus, in comparing educational achievement of several groups, it is desirable to consider the intelligence scores of individuals in the groups. The appropriate method of analysis in this situation is the analysis of covariance.

Johnson and Tsao (24) used two concomitant measures in a factorial study of educational achievement of high-school students. The purpose of the study was to investigate the effect of four factors on scores in a test of scholastic achievement given at the end of the school year. The factors were grade status, scholastic status, sex, and rank order within each grade-scholastic-sex subgroup. In addition to the scores on the achievement test given at the end of the school year, scores on the same test given at the beginning of the year and mental age scores were obtained for all subjects. The latter two measures were used to eliminate the component of variability in the final scores due to these measures from the group comparison required in the study of the various factors. All main effects and interactions were examined.

Moore (34) used chronological age and mental age as concomitant measures in a comparison of vocabularies of orphanage and nonorphanage children. Since the two groups differed considerably in both chronological and mental age, it was necessary to eliminate these sources of variation before a fair comparison of vocabularies was possible.

Johnson and Hoyt (23) compared two groups on their ability to learn physics. Three additional measures, consisting of scores on the *American Council on Education Psychological Examination*, elementary mathematics, and honor-point ratio, were obtained for each individual. The two groups were then matched on the latter three variables in such a way, that comparison between the groups could be made on each set of three scores based on these variables. The matching procedure can be viewed geometrically if coordinate axes are set up in three dimensional space and scales corresponding to the matching variables are set up on these axes. A set of three scores is then a point in this space, and the groups can be matched at each point. By examining sets of points, regions of significance and nonsignificance can be laid out. The matching procedure was achieved by calculating regression equations after the data had been obtained, rather than by matching at the beginning of the experiment.

Relations between Two Measurable Traits

The study of relations between two traits is so standard a procedure of research that it seems scarcely necessary to report on it in this review. Some of the applications may, however, be of interest. The applications reviewed here are of two kinds: (a) those dealing with prediction, and (b) those dealing with test validation.

The following studies dealt with prediction. By correlating judges' estimates of item difficulties with their true difficulties, Tinkelman (44) found that judges were quite successful in predicting item difficulty. Stalnaker (41) studied the relationship of achievement in college with scores on an entrance examination. Thorndike (43) correlated scores on the *College Board Aptitude Test* with grades on intelligence tests taken at various times prior to college entrance to determine the effect of lapse of time on the estimation of intelligence. Lantz (27) investigated the value of informing teachers of achievement to be expected of children when this expectation is based on tests administered to the pupils. Jayne (22) carried out an experiment in which ten teachers taught the same lesson and studied pupil gain in relation to the procedures of the teachers.

The following studies dealt with test validation. In order to validate a paper-and-pencil test on superstitions, Zapf (51) created a situation in which responses of students to stimuli associated with various superstitions could be observed and scored. The students were instructed to enter a room in which the stimuli were present and their behavior was observed without their knowledge. Dyer (15) used actual translations made by students as a criterion to validate objective tests of ability to translate German into English.

Use of Multiple Measures in Prediction

In an effort to find some means of predicting behavior, many measures are often made and multiple regression estimates are calculated to synthesize the diverse measures.

Lins (29) studied the possibility of predicting teaching efficiency from information available during and prior to attendance at college. Numerous measures were obtained for each of fifty-eight teachers from the application blanks filled out at entrance to college, from intelligence tests, from an autobiography, and from an analysis of teaching fitness as shown during the senior year. Three criteria of teaching efficiency were used: (a) a combined rating based on opinions of supervisors and of observers from the school of education; (b) a rating based on comments of students; and (c) a measure of gain of pupils in educational achievement. Regression equations were calculated between the measures of prediction and each of the criteria. The possibility of correlating all criteria simultaneously with the predictors by use of canonical correlations suggests itself here.

In a companion study using the same teachers and the same criteria as Lins, Von Haden (47) studied the prediction of teaching efficiency by use of subjective measures. These measures were obtained from comments of interviewers, instructors and supervisors; from an analysis of stenographic reports of interviews; from autobiographies; and from personal data. Regression equations were calculated. In another companion study, Jones (25) used objective measures based on data available at entrance to college and on college grades to predict teaching efficiency. Hellfritzsch (20) made a factor analysis of the measures used by Lins, Von Haden, and Jones. Carter and Dudek (9) used several measures in a study of plane navigators' efficiency. Regression equations were calculated using as a criterion errors in bringing the plane to a required point.

Detchen (12) investigated the value of items in the *Kuder Preference Record* in predicting success on a social-science comprehensive examination given at the University of Chicago. The items in the test were keyed by comparing responses of students who did well to responses of those who did poorly on the social-science examination. The resulting test was then included in a test battery to predict success in the examination. An important aspect of Detchen's work is the fact that she tested her key on a sample other than the one used to establish the key. This procedure was necessary, since the key contained many sampling errors and could not have been regarded as valid for the population unless tested further. A need for similar testing arises in the studies of teaching efficiency referred to above. The authors selected those groups of measures which had highest multiple correlation with the criteria, but these multiple correlations were highest only in the sample, and additional study is needed to determine whether they are highest in the population.

Comparison of Groups by Use of Multiple Measures

It is common in studies which compare two or more groups to obtain several measures on each individual, but to compare the groups on each measure separately. However, procedures are available for comparing the groups on several measures at once.

Lins (29) studied the relationship of a set of measures, which included college-entrance tests and high-school records, to admission to a school of education at the end of the second year at college. There were two groups to be distinguished, those admitted to the school of education and those not admitted. By use of biserial correlations between the two groups and the various predictors, Lins obtained a regression equation to predict admission to the school.

Baten (2) used scores based on judges' opinions of color, mealiness, texture, and flavor to distinguish between types of potatoes. Using discriminant function analysis, he obtained a set of weights by which the scores can be combined to obtain best discrimination.

The problem of discriminating between more than two groups was considered by Rostker (36) in a study of factors relating to teaching ability. Teachers of twenty-four classes were measured on many traits. Pupil gain as measured by initial and final tests was the criterion in the study. In order to determine whether the differences in pupil gain were related to the teacher measures, average pupil gain was calculated for each class, and the averages were correlated with the set of teacher measures. To eliminate variation due to differences in ability among pupils in the various classes, a regression equation was calculated for pupil gain and measures of ability. Pupil gain was then measured in terms of deviations from the regression estimates. Companion studies similar to that of Rostker but using different measures were carried out by Rolfe (35) and La Duke (26). Rostker considered each class as an individual and so had only twenty-four cases to work with, a small number for a multivariate study. Actually there were as many cases as pupils in the classes and, consequently, many more degrees of freedom for testing significance.

Sample Design in Surveys

Much greater care is often exercised in obtaining a sample when a survey is carried out than in the usual research study. An outstanding example of a carefully planned survey is that made by the U. S. Office of Education in 1946 to determine higher educational enrolments, and described by Cornell (11). The survey was based on a sample of approximately one-fifth of all institutions providing higher education in the United States. The institutions in the sample were obtained by setting up strata on the basis of category of school and size within category, and then sampling randomly within the strata. By use of mathematical formulas and information regarding enrolments obtained from previous surveys, the number of institutions to be sampled from each stratum was determined, so as to provide standard errors of preassigned accuracy.

The application of sampling methods to public-opinion polls was described by Cantril (8). Smith (38) combined survey methods with those of testing hypotheses. The purpose of the study was to determine the relationship between level of knowledge and liberal opinion. A sample of 6000 persons was obtained. For each person, level of knowledge was measured by response to four questions based on current events, and liberal opinion by response to four opinion questions. The relationship between the two measures was studied within groups which were homogeneous both as to occupation and income.

Sequential Sampling

Sequential sampling provides a modification of the usual sampling procedure, since by this method cases are obtained sequentially, one by one, or in groups. When applied to testing a hypothesis, the hypothesis is formulated and two probabilities are assigned in advance of the sampling procedure. The probabilities are due to errors in (a) rejecting the hypothesis when it is true, and (b) accepting the hypothesis when it is false. These probabilities are arbitrary, and are based on the practical importance of these errors. On the basis of the hypothesis and the pre-assigned probabilities, certain calculations are made at each stage of the sampling sequence, i.e. after each observation or groups of observations. The calculations lead to one of three decisions: (a) reject the hypothesis, (b) accept the hypothesis, (c) continue sampling. It has been found that sequential sampling reduces greatly the number of cases required for a decision as compared to ordinary sampling. The theory and numerous applications were described by Wald (48).

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CHAPTER V

Observational Methods of Research

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THE three-year period covered by this chapter was deeply affected by the war, one important effect of which is apparent in the displacement of research personnel during that period. Nevertheless a considerable quantity of research in all fields was published. The studies summarized here appear to make contributions to or to illustrate particular aspects of observational research methodology. This chapter, altho organized somewhat differently, continues the previous review of observational methods by Sells and Travers (115).

Direct Observation Technics

A wide variety of forms of direct observation for collection of basic data has been noted. Some investigators use written documents or recorded factual material as a source with appropriate technics of recording and analyzing. Others are based on observation of human behavior in action, in actual real-life, clinical, and experimental situations. Systematic studies employing direct observation of behavior have been confined mostly to infants and young children. Much useful information might be obtained by extension of these technics to other groups.

It should be noted, however, that the value of any technic of direct observation as a definitive research method depends on the rigor with which it is applied. Direct observation and especially records from direct observation are subjective. Reliability of data, or reproducibility, can be increased by standardization of procedure, by the proper use of codes or recording schedules having formally defined categories of classification, by the use of apparatus aids, such as moving tapes or stop watches for time samples, and by the use of additional observers to check on the original observer. The value of results based on these methods must be judged in part by the evidence of reliability of observations. The representativeness of the sample of population observed must similarly be evaluated.

It will be noted that many observational studies are either delinquent in their consideration of the aforementioned restrictions or else they are frankly preliminary and exploratory in nature. Some of the studies reported below treat reliability adequately. Few have remarks on the statistical adequacy of the sample population. However, each of them has some value as a representative of a particular observational procedure, and it is on this basis primarily that selection was made.

Sociological-Psychological Survey

Stroup's (119) study of the Jehovah's Witnesses was an attempt to understand this movement in its historical and social context. Using original observations of public and private practices of the sect, and many of their publications, he described the history of the movement, its organization and hierarchy, and the literature, beliefs, attitudes, and conversion experiences of the Witnesses.

Content Analyses of Documents

Davison (31) and Dallin (29) analyzed Soviet propaganda by content analysis of selections from the Soviet press. Davison selected a sample of four Russian-controlled papers for fifteen days, tabulating the number of items published according to six preselected propaganda themes. He compared these data with the total material available in the news service bureaus. Dallin analyzed the increasing proportion of anti-U. S. attitudes manifested in Soviet "news" articles and editorials. Dollard and Mowrer (33) outlined a method of measuring tension in written documents.

Analysis of Paintings

Alschuler and Hattwick (1) obtained paintings and samples of use of other creative media such as crayon work, clay, blockbuilding, and dramatic play for 150 children, two to four years of age, from five public nursery schools in Winnetka, Illinois. They studied the entire group for a year, and planned to follow up a number further. Analyses of these data were compared with expression of characteristic feelings in overt behavior. They found evidence of comparable forms of expression of universal experiences by children of different social backgrounds. Elkisch (36) studied a sample of 2200 drawings and paintings by twenty-five children. She also selected eight children, according to their group popularity by sociometric methods, whose art products were analyzed in detail. This study is interesting because of the definite analytic criteria developed in terms of rhythm *vs.* rule, complexity *vs.* simplexity, expansion *vs.* compression, integration *vs.* disintegration, and realism *vs.* symbolism. Waehner (126) studied the drawings of fifty-five college students. Both spontaneous and assigned drawings were scored according to content and to preference for certain types of formal expression (size of paper, size of form elements, quality of lines, organization of form, shading, etc.). A psychologist, a Rorschach expert and teachers then matched the personality sketches, based on these analyses, with the drawings. A high degree of identification was reported.

Factual Studies

Morton (95) analyzed the questions regarding aviation asked by 3262 children in Grades I to VIII, by tabulating the proportion of arithmetical questions concerned with number, size, and time. From this he drew conclusions regarding the mathematical interests of boys and girls at various elementary-grade levels. Baker (5) collected 9280 questions from 1402 children in Grades III to VI in sixteen cities. She analyzed them by content and considered their implications for the elementary-school curriculum. Masuoka (87) compared records of food purchases of 100 Hawaiian-Japanese families for thirty consecutive days in 1933-34 with (a) records of foods purchased by rural Hawaiians in 1928 and (b) data for Japanese in Japan. Changes in diet for the Hawaiian group were found to be in the direction of adoption of American foods.

Recording of Speech

Irwin (58) and Chen and Irwin (23) have recorded speech-sound data of infants using the International Phonetic Alphabet. Irwin presented statistical evidence of the reliability of the method, particularly for the vowel sounds. Chen and Irwin showed that at two and one-half years the infant possesses nearly the full complement of adult vowel sounds but only about two-thirds of the consonant types. Bossard (17) made transcripts of family conversations at meal time for thirty-five families and supplemented these with interviews. From these data he developed analyses concerning (a) range and meaning of family vocabulary, (b) levels of language, (c) language as a social index of occupation, religion, and social class, (d) family idiosyncrasies in communication (i.e., peculiarities, private meanings, taboos), (e) patterns of conversation (e.g., subjective, objective) and (f) speech characteristics and pronunciation. Johnson and Colley (63) had twenty stutterers read a 1000-word, phonetically edited passage, while two concealed observers recorded the duration of each stuttered movement on a moving tape. They studied the correlation between frequency and duration of stuttering movements.

Case Histories: Individual Case and Exploratory Observations

Many valuable facts, relationships, and skilled insights are frequently stimulated by observations made incidentally in other than purely research activities. The following examples were selected to illustrate the importance of such reports. Axline and Rogers (4) reported a detailed case history revealing how a skilful teacher-therapist treated a maladjusted 6-year-old boy. Clark and Barker (24) presented the verbal report of an intelligent 18-year-old Negro "zoot suiter" of his participation in the Harlem riot of 1943. Dukes (34) described two cases to illustrate the devastating effect that the (wartime) disruption of family life can have on children and their parents. Anderson (2) cited the clinical findings of eighteen aphasic cases, illustrating two types, (a) in which linguistic difficulty interfered with the development of speech, and (b) in which disorders were observed producing linguistic regression. Goldfarb (48) made extensive investigations of the life histories of fifteen adolescent children in institutions. His results supported his previous conclusions that infant deprivation results in a basic defect of total personality especially in concept formation and as an attitude of passivity and emotional apathy. The reports of Knapp and Cambria (75) and Stevens (117) used case records as their source.

Peller (101) published a list of over 100 items designed to aid teachers of children from two and one-half to six years in observing significant behavior symptoms.

Observational Research Studies

Muste and Sharpe (96) studied preschool children in two situations in order to observe aggressive behavior. Their results cover technics used by children responding to aggression and the relation of frequency and type of aggressive behavior to age, sex, and environmental background. Wellman and McCandless (128) used two technics, short sample records of child behavior and a method called "following the teacher for a full day," supplemented by intelligence and vocabulary tests, in a study of thirty-four preschool children. Newman (97) developed technics for describing the behavior of up to 100 junior-high-school pupils of each sex. Noon-hour playground behavior was rated by three judges using a composite scale of behavior patterns, each analytically characterized by paired opposites and an integral scale consisting of gross behavior characterizations of the same traits. Clubhouse behavior was rated by four judges on a scale consisting of twenty characteristics described in terms of the two extremes and the middle of a seven-point scale, and twenty other traits described by a single adjective or phrase of each extreme. These ratings were supplemented by narrative and conference records on the behavior situations. Her report covers reliability data for the ratings and examples of the scales used. Lannert and Ullman (78) made a valuable study of piano sight reading by observing nine advanced students play unfamiliar selections. Their analysis resulted in some important conclusions concerning the development of skill in reading musical scores. Van Bruggen (123) studied factors affecting regularity of the flow of words in written compositions by observing and recording mechanically the time required for writing each word, and the number and length of pauses between words, in three types of composition written by eighty-four pupils in Grades VII, VIII and IX. These observations were interpreted in relation to kind of composition, M.A., C.A., and scores on reading, vocabulary, and spelling tests, as well as personality measures.

Analysis of Radio Programs

Katz and Eisenberg (67) and Peatman and Hallonquist (100) reported studies using the *Lazarsfeld-Stanton Program Analyzer Test.* This method enables each member of an audience to indicate continuously by an individual signal, objectively recorded, his like or dislike for every moment and part of a radio program. Katz and Eisenberg found that listeners do not reject educational programs as such, but want them to be entertaining.

Longitudinal Studies—Biography

This heading implies two different approaches; yet each involves consideration of the development of the individual in the perspective of his life span. Gesell, Ilg, Ames, and Bullis (47) have produced an important longitudinal study, based on periodic clinical examination of fifty children from a prosperous American community, at five, five and one-half, six, seven, eight, and nine years. A smaller number of ten-year-olds were examined. The investigation covered a wide range of individual and social behavior, which was treated in terms of growth gradients and growth trends. Koshuk (76) made a preliminary report of 500 developmental records collected over a three-year period in two California nursery schools attended by children of employed mothers. The records included a preentrance interview with the mother, observational notes and semester reports by teachers, and an interview with the mother when the child was withdrawn from the nursery school. Her analysis was concerned primarily with changes in home behavior and social adjustment.

Hill and Ackiss (53) suggested the use of the life history method, based on detailed, intimate, insight interviews, as a method of understanding the attitudes, feelings, and beliefs of special groups, and obtaining a more complete understanding of the dynamics of race relations in our society. They presented three condensed life histories together with their analysis of each in reference to the problems of an all-Negro community. They believe that this methodology especially lends itself to the study of race relations, since it focuses attention on the irrational, emotional, and psychic quality of racial attitudes; that it bridges the gap between the factual community survey and the personality-culture study.

Kelley (70) discussed the autobiography as a useful diagnostic and therapeutic tool in psychiatry. It is a source of information concerning the individual; it has diagnostic value with reference to the quantity and form of the patient's writing; it focuses on the patient's problems; it is an instrument of catharsis and helps the individual know that he is helping himself.

Ratings, Rating Judgments, and Rating Scales

While direct observation frequently involves judgments by the observer, these judgments are primarily descriptive and classificatory rather than evaluative. Rating judgments involve observation as a source of information, but the emphasis is on evaluation. A critical appraisal of rating judgments as an instrument of research must recognize the requirements of reliability and sampling. These two problems are interrelated in ratings, inasmuch as one source of unreliability of ratings is the peculiar set of biases occurring between samples. These include (a) differences in sample composition in attributes of members, (b) differences in standards or criteria employed by different raters in relations to different samples, (c) different biases and halos affecting raters with regard to different samples. The validity of ratings, however, is the most critical problem. This is the question of identification of the attribute or function rated with the true representation of the attribute or function, and is usually demonstrated by correlating the ratings with a suitable criterion.

Assessment of Men

The psychological division of the Office of Strategic Services, under the leadership of Henry A. Murray, developed valuable technics of assessment by which personnel were evaluated and selected for wartime assignments of highest requirements and responsibility. One of the significant aspects of the assessment program was the emphasis on an interpretive synthesis of the whole person, in contrast to the elementaristic approach so much in vogue. MacKinnon's report (82) describes the method.

Rating Scales

Metfessel (91) proposed that a scale of cardinal numbers be used in expressing comparative judgments so that the subject either actually or symbolically manipulates units of the ratio scale of cardinal numbers in expressing his judgments of quantitative relations among the items on a given dimension. He claimed that this method causes comparative judgments to be made with greater sensitivity than is the case with ordinal scales and individual differences are likely to be given more consideration by judges using this method.

Weinland (127) outlined a technic for improving the reliability of rating scales by obtaining descriptive words for rating scales, which will be in the workers' language, and will be conducive to using the whole scale without overloading at the average. The method involves first writing a list of descriptive terms for a particular characteristic, then evaluating each word by placing it on a nine-point scale, and finally selecting the best words for a five-point scale at the approximate relative positions of two, four, six, and eight. Kelly (71) presented a useful technical report on the development of a scale for rating pilot competency. He described the method of developing the scale and the data on item interrelationships. The preliminary "man-to-man" graphic scale covering skill, emotional stability, and judgment was discarded because of high intercorrelations between traits, indicating lack of independence. The final scale combined the best points of several other attempts into a fourteen-item graphic scale. A factor analysis of item intercorrelations of this scale showed that three factors, (a) skill, (b) judgment, and (c) emotional control account substantially for all of the variance.

Rating of Applicants for Positions

McCoy's (88) comprehensive report described trends and research in evaluation and rating of Federal Civil Service unassembled examinations. Job analysis precedes and forms a basis for examining technic, which considers applicant's training and experience records, supplemented by various documentary and interview evidence. Examiners evaluate applications numerically on rating schedules. The current emphasis is on quality rather than quantity of qualifications. A refinement of procedure was the establishment of rating factors, based on the specific skills or abilities needed. Quality ratings on a graduated scale were assigned to applicants on rating factors established on the rating schedule for each position. Brody (20) described a method he developed for judging candidates by observing them in unsupervised group discussion. Ten to twelve candidates are observed at a time, and each may be asked to speak for three to five minutes on some selected topic, following which all participate in group discussion. The employer-interviewer is free from participation and may devote all his attention to observing and rating candidates. Brody cites how the New York City Department of Health has used this group method, judging candidates for appearance, manner of speech, attitude toward the group, leadership, contribution to group performance, and scientific approach.

Rating of Teachers

Seagoe (114) found that the success of twenty-five teachers, after two years of service, measured by ratings by school administrators directly over them, was correlated with test scores on personality, emphasizing mental health, obtained while they were in training. Prognostic tests of teaching ability given at the same time showed no predictive ability. She also found relatively high correlations with the criterion for training teachers' judgments of teaching success, but not for grade-point ratio. Von Haden (125) used a composite of five supervisory ratings, pupil evaluations, and pupil gains as criteria, and interviews, digests of interviews, autobiographies, and instructors' and supervisors' ratings during teacher training as predictors, in a study of fifty-eight women teachers in first-year positions. He found that subjective personal data correlate most highly with supervisory ratings of teaching success, but are not closely associated with objective measures of teaching effectiveness as indicated by pupil evaluations and pupil gains. Barker (7) used personal interviews and case studies, as well as ratings by superiors in a study of personality adjustment of teachers. School principals in consultation with their general supervisor selected three teachers from each of twenty schools, on the basis of (a) the best teacher, (b) an average teacher, and (c) a below-average teacher. Her findings showed a marked pattern of relationship of adjustment measures to efficiency in teaching.

Merit Ratings of Personnel

Probst (106) described his *Probst Rating System* with examples for a variety of occupations, together with technical treatment of item selection, foreign translations, oral interviews, and experimental procedures. Ryan (111) argued that the logical difficulties and practical inadequacies of graphic rating scales with numerical scoring are bad enough to offset any advantages claimed for them, and suggested a simple scale for merit rating until more adequate means of measuring an employee's value can be found. This is a three-point scale ranging from outstanding thru average to poor, restricting extremes to the upper and lower 10 percent. This type of scale employs judgments which can be made with some confidence, altho it has compensating shortcomings in the massing of the middle 80 percent. It can be refined somewhat by requiring separate judgments on special qualifications and abilities, such as dependability, specialized technical knowledge, ability to instruct others, and ability to get along with others. Mahler (84) prepared an annotated bibliography covering employee rating methods, administration of merit-rating programs, types of rating methods, and research and reports on the use of merit ratings. In another paper Mahler (83) reported a survey of current practices in employee rating in 125 companies, in which most of them use a scale method. A total of 131 different traits were listed on these scales, which generally were individual scales using from one to thirty-three traits which were often poorly defined and overlapping. The number of degrees for rating each trait ranged from three to sixteen. Ferguson (39) developed an employee merit-rating system for a large company. This system was especially designed to measure the factors having a direct bearing on the success or failure of a group of workers on identical jobs. He described the development of the system and the experimental work of validation.

Ratings of Courses by Students

Barkley (8), Fowler (41), Marsh (85), Savage (113), and Taylor (122) investigated the appraisal of courses by students. In general, favorable ratings predominate. These ratings seem to be unrelated to scholastic aptitude, altho Savage found a tendency toward less approval associated with low grades. Fowler reported that students generally rated their instructors higher than the instructors rated themselves. Both students and instructors believed the ratings "served a good purpose." Taylor and his associates discussed arguments for and against such ratings which they believe valuable for the teacher and the administration but reported that the majority of the Smith College faculty recently voted adversely on this issue.

Ratings of Social and Personal Factors

Anderson (3) had the male and female heads of 344 New York farm families rate their own families on a four-point scale with respect to two indicators of social status and three indicators of social participation. Ratings of status were higher than those of participation. Analysis of ratings in relation to objective measures of social status and social participation showed that most participation and leadership activities are not only carried out on the basis of social standing in the community, economic position, tenure status, and family maturity, but also as an expression of the opinion of the family about its own social position. Remmers and Kerr (109) measured cultural, aesthetic, and economic aspects of the home environment of 16,445 eighth-grade children in forty-two cities in twenty states by means of the *American Home Scale*. The cities chosen were approximately equally spaced in Thorndike's G scale. Correlations of city averages with Thorndike's G (goodness of living), I (income), and P (personality) indexes are low and not significantly different from zero. The authors believe that the *American Home Scale* has higher face validity and measures more directly and validly goodness of living, functional income, and personal factors than do the Thorndike scales. The treatment of validity in this paper is of interest inasmuch as there is no independent criterion by which to judge the conclusion. Kaufman (68) studied biases in ratings in an interesting fashion. He had fourteen individuals judge the prestige rank of members of a New York rural community and studied the judgments with respect to agreement with judgments of other raters, objectivity and discrimination in judgment, and biases evident in judgments. Results showed that despite high correlations of individual with composite group judgments, individual objectivity (ability to distinguish between personal likes and dislikes and the way in which a person is regarded in the community) varied considerably, and to some extent the judge's objectivity seemed to be influenced by his own prestige rank. Individual bias also varied considerably, apparently heavily determined by the judge's attitude toward the social group with which the person rated was affiliated. Goodenough (49) had ten men and ten women judge the sex of 115 high-school students from specimens of their handwriting and report degree of confidence of the judgment on a three-point scale. Identification judgments were correct in about two-thirds of the cases, with no sex difference in success of judgment. However, all women judges' confidence judgments exceeded the median for the men, and a positive correlation was found for both sexes between accuracy of judgment and confidence. Rokeach (110) studied factors affecting judgments of beauty by college women. Using five separate groups, he had each subject rate herself and each other member of her group on beauty. He obtained three scores for each person: (a) average rating by all others in group, (b) self rating, (c) average rating attributed to others. The results indicate in part that persons below the average of the group tend to overestimate their own beauty, that those who have insight into their own possession of beauty tend to be objective in rating others, and those who have a high degree of beauty tend to be objective in rating others regardless of degree of insight. Mitchell (93) presented two high-school classes numbering seventy-five with a schedule entitled "Types of Persons I Have Met." This list contained forty-four classifications, such as Alibi-Ike, Goody-Goody, Honest Type, Pussy-Foot, and Tough. Each student was asked to write in each category the name of a classmate who best fitted it. He found considerable agreement on judgments in both classes which he interpreted in terms of the tendency for a person's social stimulus value to be consistent. Jacobson (61) divided a freshman class of 285 women into eleven groups and had each member evaluate her group mates on appearance and behavior. She analyzed 9076 responses into forty-nine subtopics and classified these into five categories. The result was that responses of a psychological nature were most frequent, with grooming second, physical characteristics third, clothing fourth, and intelligence fifth. Favorable evaluations were more frequent than unfavorable or neutral ones.

Sociometric Ratings

Sociometry is not a new method. However, the wide applicability and adoption of sociometric measures in the study of problems of group dynamics is one of the conspicuous occurrences of the current period. Moreno (94), its originator, discussed the contributions of sociometry to research methodology in sociology in the study of intergroup relations, as distinguished from its twin study of interpersonal relations. The following papers by Potashin (104), Olson (99), Bonney (15) (16), Blanchard (12), and Jacobs (60) are concerned with studies of interpersonal relations. In her study of children's friendships, Potashin defined friends as pairs of children in which each gives to the other the highest choice in a sociometric test in a classroom, while nonfriends are pairs in which one gives the other his highest choice, but the latter does not reciprocate. She compared friends with nonfriends and found that sociological factors are of little significance in determining friendships, while physical or intellectual similarity are even less significant; a child who is one of a pair of friends is usually well accepted by the group while a nonfriend is not so well accepted. Friends also seemed to participate in group activity more and to require less adult direction. Olson reported a highly interesting experiment in which a sociometric analysis of a third-grade class, supplemented by studies of family and community relations, was the basis for a successful effort to improve human relations among the children in the classroom. The study also gave rise to a conclusion that children's social relations in a classroom have deep roots in community and family living as well as in the physical, mental, and emotional differences among the children. Bonney asked 100 sixth-grade children to indicate individually with whom they played most often, and those whom they would prefer to have on their side for a quiz-kid program. He studied the amount of reciprocating between those chosen rarely and those chosen frequently. The tendency of the low group to choose high group more often was more pronounced in choice of quiz-kid teammate than in choice of playmate. Jacobs asked seventeen girls in the same office, individually, to name those with whom they would prefer to work in close proximity. The tabulated results revealed certain attractions and repulsions among the girls which were not known to the management of the firm, but which nevertheless probably affected office morale and productivity.

Interviews

Perhaps the most ambitious and scientifically rigorous investigation of human behavior ever undertaken using the interview as a method of data collection is the so-called Kinsey (72) survey of sex behavior. At the time of this report, 10,500 case histories were completed, based on first-hand interviews with persons "of wide social range, of all ages, and diversity of educational, occupational, religious, and rural-urban backgrounds."

The interview is a basic method of research, as above, as well as of evaluation, guidance, and therapy. The following group of studies illustrates methodological aspects of the interview method.

Projective Technic in Interviewing

Pepinsky (102) described how he used a lithograph of a bleak landscape on the wall in his office in the manner of a Rorschach card. As a counselor, he directed the client's attention to the picture during the course of a counseling interview, without making the client suspicious or hostile. He claimed that this technic provides a release of tension for the subject and a possibility of diagnosis by uncovering hidden motives. Rautman and Brower (108) used ten pictures from the *Thematic Apperception Test* in interviewing 536 public-school pupils in Grades III to VI and their twenty teachers in December 1943. Each pupil or teacher wrote a brief story about each picture and answered the following questions: (a) What is happening? (b) How are they feeling? (c) How will it end? The resulting data were examined for evidence of war-inspired themes. Symonds (121) used forty-two pictures, especially drawn for the study, each containing at least one adolescent figure with which an adolescent might identify himself. He secured stories on each picture from twenty normal boys and twenty normal girls in junior- and senior-high school and tabulated the number of themes presented. In this preliminary report he stated that the count of themes presented should serve as normative data against which to compare fantasy productions of individuals and groups.

Interview in Casework

Voiland, Gundelach, and Corner (124) formulated a casework approach intended to assist the caseworker in the diagnosis and treatment of people and their problems from the very beginning of casework. They stressed the importance of developing rapport in the first interview and the need for meeting the client on his own ground. Kay and Schick (69) described the "role-practice" method of training interviewers in developing skill and insight. A study of social conflict in a community of mixed ethnic groups required that interviewers obtain information with regard to informants' intimate, private attitudes. Interviewers were trained by practicing, in succession, each of several roles representing different approaches of the interviewer, i.e., friendly, inquirer, stranger, analyst.

Interview in Evaluation

Newman, Bobbitt, and Cameron (98) reported reliabilities of from .83 to .85 in independent interview ratings by two psychologists and a psychiatrist with 399 Coast Guard Reserve officer candidates and 137 SPAR officer candidates. The bases of evaluation were complex and covered (a) ability to pass academic training, (b) ability to withstand psychological pressures and tensions of the training program, and (c) ability to withstand the trauma of combat and demands of service life. Ratings were on a thirteen-point scale. The report covers factors influencing reliability.

Patterned Interview

McMurry (89) cited several studies which revealed the extent to which interviewers using the patterned interview were able to predict ultimate job success. The patterned interview usually is a printed form containing specific items to be covered and providing a uniform method of recording information and rating the interviewee's qualifications. The principal advantage of the patterned interview is that it eliminates much of the guesswork and provides greater uniformity of results.

Interviews in Research

Huang and Lee (56) used interviews in an experimental study of child animism. They asked twenty children from six years to eight years seven months questions about a dog, tree, river, stone, pencil, bicycle, ball, automobile, watch, and the moon. The children indicated whether they believed the object was living, had life, felt pain when pricked, was capable of wanting, could be good, had anything it must do (function), and performed this purposefully; then they amplified this statement. Results were analyzed in terms of animistic beliefs and in relation to age. Duvall (35) interviewed ten fiancées and sixty-seven wives of servicemen to study the effect of wartime separation of women. He found that loneliness was mentioned most and was a function of the degree of social participation, the more active wives being less lonely. Witty, Coomer, and McBean (130) secured interviews with children in kindergarten and the first three grades, and questionnaires for children in Grades IV thru VIII, totaling 7879, to ascertain their favorite books or stories. The children's selections agreed closely with lists of books selected by adults. Maturation of interests was observed from grade to grade. The report lists preferred books, with rank awarded to each, for kindergarten, primary, intermediate, and upper grades. Jones and Arrington (64) made a qualitative and quantitative study of the explanations of physical phenomena given by 161 Negro and 134 white children in Grades III to VIII to find whether there is justification for a belief that Negroes are more superstitious than whites. The results did not support this hypothesis; very few answers in either group indicated belief in either the supernatural or in superstitions.

Questionnaires

The questionnaire is undoubtedly the most frequently used of all observational technics, having obvious advantages in administrative economy of time, money, and effort over other methods. However, savings accomplished by this method are frequently made at the sacrifice of sincerity, completeness, reliability of response, and validity of interpretation. Technics of questionnaire construction and standardization are well established. It appears that they are too often disregarded, however, because they involve expenditure of time, effort, and skill which compensate for savings accomplished in administration. Unfortunately many studies are published which use questionnaires uncritically and without adequate preparation.

Studies of Questionnaire Technic

Marsh (86) demonstrated the influence of set or attitude created thru verbal instructions upon responses to questionnaires. He gave two groups of college students a fifty-seven item form entitled "Campus Issues Inquiry." One group was instructed to judge the items impersonally, while the other was told to judge the items in terms of their own personal experience. Significant differences were found for items considered critical issues. Gerberich (45) made a study of consistency of responses to questions, using sixty questions, some dealing with fact and others with personal and social adjustment, selected from professional application blanks and attitude and personal adjustment questionnaires. These were interspersed with others in three ostensibly different questionnaires and administered on three successive occasions to 657 college students who were not told that the selected questions were repeated. The consistency of each person for each question was analyzed; for one-day intervals it was 76 percent, for ten-day intervals 74 percent; percent for women slightly higher than for men; and percent for factual questions lower than for attitude-adjustment questions.

Questionnaire Investigations

The following studies demonstrate types of problems which have been investigated successfully using questionnaires. Baker and Peatman (6), covering a full sample of Veterans Administration advisement units in operation on July 1, 1946, sent the director of each unit a questionnaire asking him to indicate the tests which he found most useful in his unit. This type of investigation, requesting concrete information, and covering a complete sample of qualified respondents represents an optimal use of questionnaire technic.

Cupps and Hayner (28) gave a sample of 182 men and 132 women students at the University of Washington a three-page questionnaire inquiring into their experiences and feelings about dating. Kirkpatrick and Caplow (73) at the University of Minnesota obtained information from students on courtship problems. Brav (19) had fifty women, married from two to twenty-seven years (average twelve and one-half) in a small southern community, fill out a detailed intimate questionnaire giving their views on the honeymoon, based on their own experience. As in these three studies the questionnaire is often a good vehicle for obtaining intimate, personal information, provided respondents are properly motivated to answer frankly, their identity is adequately concealed, preferably by keeping replies anonymous, and the information requested has not been distorted by forgetting.

Wittenborn, Larsen, and Mogil (129) used two questionnaires regarding study habits, one in French and one in Spanish. Each included items relating to personal and emotional reactions, knowledge of subjectmatter, skill, and study technics. They gave these to college students and correlated the responses with objective indexes of academic performance. It was found that a large and useful group of study habits is significantly related to the criteria. Stoughton and Ray (118) had 344 children in Grades II, IV, and VI answer the following questions: "Of all the persons whom you have known, or heard about, or read about, whom would you most like to be like? Why do you like this person?" They used a questionnaire form in the two higher grades. Responses, segregrated by grade and sex, were tabulated under three broad categories of persons or characters: (a) those in the child's immediate, everyday environment, (b) those in remote places, including imaginative and fictional, and (c) those in religion. Horrocks and Thompson (55) studied the degree of friendship fluctuation in adolescent friendships in a rural group of 421 boys and 484 girls from ten to seventeen years. On each of two occasions, fourteen days apart, each one was asked to list his or her three best friends. An index of friendship fluctuation was computed and data were analyzed by sex and age. Harris and Watson (52) attempted to answer the question "Are Jewish or Gentile children more clannish?" thru a questionnaire to eighty-two children in grades four to six of an upper-class private school in New York. Each child was required to list his three best friends under three conditions: (a) choice limited to members of his class, (b) choice limited to children attending the school, and (c) choice limited to children outside of school. Altho the sample was highly restricted, the design of this study is interesting. The results were analyzed directly by comparison of percent of in-group and out-group selections under each category of response. This treatment permitted the conclusion that Gentile children were less likely to choose Jewish friends than were Jewish children to choose Gentile friends.

Pratt (105) and Zeligs (131) studied children's fears and annoyances respectively using the open-question group-response technic. Pratt had a group of rural children from four years to fifteen years ten months, list their current fears, indicating three things feared most and three feared least. Responses were analyzed by grade and sex. Evidence was found of cultural stereotypes, such as fears of lions or tigers. Zeligs had sixth-grade boys and girls of two suburban Cincinnati schools list things which annoyed and irritated them. She then classified the responses into twelve categories, ranging from social relationships to environmental conditions, and incorporated them in a rating scale with response categories from *like* to *hate much*. The following year she presented this rating scale to 285 of the same children and tabulated their response by categories. Clear patterns of sex differences were found.

Mass Surveys

Mass surveys of large samples of respondents are recognized today as, as well as by, big business. They include market surveys, attitude and opinion polls; they use various types of questionnaires and interviews; and collect data by personal interview, by mail, and by various combinations of these. Some interesting developments were sponsored by government agencies during the war, such as a consumer panel, in which a continuous sample of respondents furnished daily information on purchases of rationed foods, to assist the rationing agency in setting point values. Consumer panels are used to study brand preferences, readership interests, or any other specific problems which a sponsor is willing to underwrite.

All these procedures have certain things in common. They secure information from people, using sampling technics, with relatively large numbers of respondents, and attempt to develop generalizations from the samples concerning the whole or a substantial segment of the population. Notwithstanding these similarities, however, there are wide differences in technic of securing information and in sampling required for different problems in this general field. These problems of method have been widely discussed in the literature.

General Discussions

One of the most comprehensive discussions is McNemar's (90) critical review of opinion-attitude methodology, in which he carefully analyzed the issues involved in measuring attitudes by scaling technics, in single-question opinion gauging, in the administration of tests, in statistical treatment and sampling, and in conducting morale surveys. Katz (66) wrote a critical comment distinguishing what he called "survey technic" from opinion polling. He holds that the single-question type opinion poll is applicable only on issues where public opinion is crystallized and to which unambiguous questions can be addressed. In such cases, a "cross-section" sample may serve adequately. The "survey technic," on the other hand, is necessary in approaching issues in which public opinion is not crystallized and requires the use of plural devices, subtle and often indirect indexes, more complex sampling and above all careful consideration of scientific method in the analysis of such variables. The "survey technic" was applied by government agencies during the war to the measurement of morale in war industries, and in studying morale as influenced by strategic bombing in Germany and in Japan. Campbell (22), in a companion article, emphasized the limitation of polling to questions that are well understood by the public and are clear-cut. For the remaining questions he recommended "open interviewing," which reveals not only the respondent's yes or no answer, but his interpretation of the question and the intensity of his feeling about it. Bernays (9), addressing himself only to attitude polls and excluding factual and purely quantitative surveys on markets, elections, and similar issues, argued that polls are useful when used as a guide to current opinion, since they cover only a temporary attitude. He was concerned with the prevention of misuse and misinterpretation and recommended licensing sound and ethical polling agencies and educating the people and public leaders in the social significance of polls. Blankenship (13) edited a symposium to which twenty-nine specialists contributed articles dealing with specific aspects of consumer and opinion research and sampling technic as practiced in business, industry, government, and agencies reporting to the public. Ferraby (40) discussed the qualitative and quantitative technics of mass-observation in England.

Technical Papers

Slight differences in phrasing, order of questions, and like variations, often yield different proportions of favorable and unfavorable responses. Suchman and Guttman (120) described an objective method based on Guttman's technic of scale analysis and intensity analysis of dividing the responses into pros and cons so that the division is not affected by wording or similar variation. The method results in an intensity curve, the lowest point of which will be the same for any sample of questions from the same scale or dimension of opinion. In another paper, Guttman (51) described the technic of scalogram analysis, a method of quantifying qualitative data.

Gallup (43), in reply to criticism of public-opinion measuring, described a system of question design which has been evolved out of many years of research by the American Institute of Public Opinion. This method provides an opportunity for probing five aspects of opinion: (a) filter and information questions to find out if the respondent has given any thought or attention to the issue, (b) open or free answer questions to get at unstructured opinions and reveal the direction of the respondent's thinking, (c) dichotomous or specific issue questions in which the public is asked to stand up and be counted on specific issues, (d) questions asking respondents why they hold the opinions they do, and (e) questions to measure the intensity of opinions. It is apparent that most critics have viewed the pollers as practitioners of the dichotomous type of question more or less exclusively.

Campbell (21), in discussing the open-question technic, pointed out that open questions are useful in revealing general attitudes and suggestions about the sources of opinions, but they permit variation in frame of reference and thus allow avoidance of the desired response or make difficult the classification of responses. The questioner must be alert to follow up with added questions to clarify responses.

Connelly (25) pointed out that adequacy of sampling procedures and reliability of results are subordinate to the major problem of validity, which is adversely affected by (a) interpreting a specific response apart from its specific stimulus, (b) failure to write poll questions in terms of the objective behavior in which the poller is interested, (c) believing that the respondents must think clearly (according to the poll author's concept of clear thinking), (d) assuming that the respondents need to know the implications of their opinions to answer validly, and (e) incorporating prestige factors into the complex of questions.

Dodd (32), recognizing the growth of the survey industry, has pointed out the need for, and outlined some forty dimensions of excellence as a basis for standards for surveying agencies. These are divided into six major groups: agency credence standards, questionnaire standards, sampling standards (with some statistical details given), interviewing standards, reporting standards, and administrative standards. These are unquestionably worthy of any research agency.

The questions of administration of field work in large-scale surveys have been discussed by Bevis (10) and by Huey (57). Bevis covered training and supervision of resident interviewers. Huey outlined the special problems and special skills arising in large-scale, organized research. He described the organization and administration of the Morale Division of the U. S. Strategic Bombing Survey in Japan.

Frazen and Lazarsfeld (42) analyzed certain problems in the use of the mail questionnaire. They mailed questionnaires to a sample of 3000 *Time* subscribers, 1000 each of three slightly different forms. Five hundred five respondents and 882 nonrepliers were personally interviewed. The results are stated to indicate that mail questionnaires can produce valid samples of comparatively homogeneous groups and that the answers to some questions given in a mail questionnaire are more informative and more freely given than the answers the same people give to the same question when face to face with an interviewer. They recognized, however, that significant biases do occur in mail returns, and precautions must be taken to avoid prejudiced generalization.

Guest (50) compared the results of a consumer jury test carried out by magazine votes with one carried out by personal interview. He found that the difference was considerable tho not statistically significant.

Illustrative Studies

The following references illustrate some of the major categories of mass-survey technic, described above, as follows: reader panel: Corson (26); opinion study of a special population segment: Hollis (54), Peterson (103), Faterson and Klopfer (38); information survey: Mills and Atkinson (92), Endicott (37), Kwoh (77); attitude survey: Blum (14), Crespi (27), Smith (116), Samuelson (112).

Combinations of Observational Technics

Several studies have combined several different technics in a manner which justifies special mention. Kitay's (74) investigation of attitude toward religion made extensive use of personal documents, such as autobiographies, essays by students on their attitudes, responses to personal data questionnaires and attitude questionnaires. His study was based on 139 Jewish students of the Commerce Center of the College of the City of New York in 1941 and 1942. Radke (107) investigated parental authority and discipline in the home environment and its correlates in the child's attitudes and social behavior by a number of methods, including questionnaire and interview reports from both parents and children, ratings of personal-social behavior by teachers, and tests, experimental situations, and projective technics on the children. The subjects were forty-three nursery school and kindergarten children, averaging four years eight months in age, from urban homes, representing a select social, economic, and educational sample of the population. Radke found that the projective interviews with the young children yielded valuable data in locating critical areas in the child's home relations and in getting his reactions to known home situations.

Observational Instruments and Aids

Photography

An outstanding photographic study is that of Gesell (46) which summarizes the physical and social growth of a baby in 800 photographs.

Eye Movements

Brandt (18) developed a camera which permits simultaneous recording of vertical and lateral eye movements. This is a valuable device for many types of research in reading, attention, illumination fatigue, and related problems.

Hearing Aids

Davis (30) reported experimental findings and acoustic recommendations on the design objectives of an ideal hearing aid. Gates and Kushner (44) did a research of extreme importance and interest on the factors influencing the decision of children to wear hearing aids. Using tests and extensive interviews they discovered many social and personal factors of controlling importance which can be adopted in the more effective design of hearing aids. Lorge (81) found on audiometer retests after two years of a group of twenty-five hearing aid users and a control group of equal size, that there was no significant difference between aid users and the control group in amount gained in hearing-speech capacity.

Physiological Measures

Bitterman (11) using continuous electromyographic recordings of cardiac and eyelid activity, obtained while subjects performed visual tasks in two different experiments involving reading material in six- and ten-point type at three and at ninety-one footcandles of illumination, found no evidence that either heart rate or blinking rate is an index of the ease of visual work. Loftus, Gold, and Diethelm (80), in an investigation of electrocardiographic changes accompanying intense emotional states, found evidence which pointed to the possibility of psychogenic origin of the electrocardiographic changes. There was no evidence of cardiovascular disease. Lennox, Gibbs, and Gibbs (79) observed identical electroencephalographic tracings in 85 percent of fifty-five pairs of monozygotic twins. Results of their study indicated that the brain wave pattern is hereditary and that the encephalogram can be used in human genetic studies.

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CHAPTER VI

Tests and Measurements

WILLIAM B. SCHRADER and HERBERT S. CONRAD

ACHIEVEMENT testing, broadly conceived, constitutes the basic topic of the present chapter. In preparing this summary, recognition has been given to the fact that certain other issues of the REVIEW cover measurement in specific subjectmatter fields. Some overlap may occasionally be observed within the fields of intelligence, special aptitudes, or personality, in the case of studies having implications for achievement testing.

Persistent attention to long-standing objectives characterized achievement testing during this triennium. Basic conceptions in achievement testing were clarified and extended. Progress toward greater directness of measurement was substantial, tho gains in this direction were generally made at the expense of objectivity or factorial purity. The distinction between the measurement of detailed subjectmatter content and the evaluation of general educational outcomes was sharpened. Numerous large-scale testing programs were energetically conducted.

Promising fields in which too little work was reported included: (a) utilization of research data offered by cumulative records; (b) long-term, follow-up studies of the retention of knowledge and skills during and after the school years; (c) effect of differing motivation and curriculum emphases upon intercorrelations of achievement test scores; and (d) development of improved criteria for validating aptitude and achievement tests. In general, the greatest needs at present relate to test evaluation, test methodology, and the effects of testing upon broad educational objectives.

Textbooks and Reference Sources

The late C. C. Ross (104) completed a revision of his textbook on educational measurement, taking account of recent contributions in the field, but placing relatively little emphasis on statistical developments. He also prepared a workbook (103) to accompany the revised text. Another workbook was prepared by Remmers and Gage (101), for their measurement text. Adkins *et al.* (1), wrote a practical, generally useful book on achievement test construction, with particular reference to civil service work. The chapter on performance testing should be especially valuable. A new book on guidance technics by Traxler (138) includes an annotated list of widely used achievement tests, along with other valuable material on the use of tests. Crawford and Burnham (25), in their book on forecasting success in college, presented a thoughtful analysis of achievement testing at the college level. Wood and Haefner (154) wrote a book on guidance and testing in a highly popularized style.

In the field of bibliography, Hildreth (68) prepared a supplement to her earlier bibliography on published tests, bringing it up to date as of 1945. Swineford and Holzinger (121, 122, 123) issued their annual annotated bibliography on statistics, theory of test construction, and factor analysis. Finally, mention must be made of the new edition of Buros' important *Mental Measurements Yearbook*, publication of which is likely to fall just beyond the time period covered by the present summary.

Test Construction

The development of new tests within subjectmatter fields is most appropriately discussed in issues of the REVIEW pertaining to these fields. Notices of newly published tests also appear in *Psychological Abstracts*, the *Journal of Consulting Psychology*, and *Educational and Psychological Measurement* (44, 45). The present summary is concerned primarily with tests developed for research purposes, or those which present some feature of general interest.

New Tests

Tests were developed according to logical analyses of subjectmatter fields by Harris (63, 64), Spache (114), and Ebert (43). Harris sought to measure seven logically discriminable aspects of the comprehension of literary materials. He designed an experimental test in which seven reading selections (including poetry and prose) were used, and in which items were systematically constructed to represent the various kinds of tasks. Factor analysis, of the bi-factor type, led him to conclude that a single common factor accounted for the intercorrelations among scores on the seven aspects of behavior. The seven reading selections used also were found to yield only one factor. Spache developed a test of arithmetic reasoning, broken down into five logical aspects, corresponding to five stages in the sequence of solving arithmetic problems. He was thus able to secure five part-scores. The intercorrelations of part-scores were apparently computed for widespread groups, and in consequence are difficult to interpret. Ebert developed a test of generalization abilities in mathematics suitable for eighth-grade students. Three types of performance were required: (a) given several mathematical statements, to write another example of the common principle; (b) given several mathematical statements, to write a verbal statement of the common principle; and (c) given a verbal statement of the common principle, to write a mathematical example. Rather high intercorrelations were found among the various types of items.

Other tests of considerable interest were developed in connection with specific educational research problems. Malter (80, 81) prepared a test of the ability of children to read diagrams involving simple symbols and another test for ability to read cross-sections. These tests were designed to determine whether or not children in Grades IV to VIII could use such aids in printed materials. Reiner (99) constructed a test of cause and effect suited to ninth-grade science students. Students were required to state whether a condition in a given sentence was (a) a direct cause, (b) an indirect cause, or (c) no cause of an event in a second sentence. Using a thirty-five minute, seventy-eight item test, he obtained a reliability of .91.

Grener and Raths (59) prepared an interpretation-of-data test suitable for children in the third grade. Horrocks and Troyer (70) developed a case-study test similar to Baller's "Case of Mickey Murphy." The three cases used were carefully constructed to provide adequate coverage of main topics in mental hygiene and adolescent psychology. Items were designed to measure ability in diagnosis and remediation. Troyer (139) described the procedure used in building a more satisfactory master's examination for students of education. The test included a section on the interpretation of professional data and a section which required the student to evaluate the appropriateness of an action or decision in relation to a specific situation. Troyer noted that there was some initial frustration on the part of students when this type of examination was used. Nevertheless, the value of the test for diagnosis and its close integration with objectives were considered desirable features. Angell (6) described the preparation of a test in educational philosophy. Among other things, the test required students to evaluate a series of statements in terms of each of the three schools of thought, and to rank groups of educational issues in order of importance. Robbins (102) used a test in which students were required to evaluate adequacy of reasons for certain opinions. He found that college students performed slightly but significantly better in identifying correct reasons for views with which they agreed than for those with which they disagreed. Bottorf (15) developed a test of art appreciation stressing art in everyday experience. Students were required to express preference for various objects. Evidence for validity of the test as a whole was found in the relationship between mean scores and the amount of art training a student had received. Nahm (90) prepared a situation-response test on mental hygiene for use in a survey of student nurses. She found that about two-thirds had a relatively sound viewpoint, as judged from test performance, but about one-fourth showed a definite lack of understanding.

Problems in Test Construction

The yearbook of the National Society for the Study of Education on the measurement of understanding (91) made what appears to be an important contribution to testing. For each major field of school achievement, thoro consideration was given to an analysis of objectives and to the presentation of illustrative items dealing with ways of testing or observing the desired pupil behavior. Brownell and Sims discussed eight essential characteristics of understanding and Findley and Scates formulated nine general principles to guide the measurement of understanding. This yearbook represents a very useful source of test ideas for measuring broader objectives in subjectmatter fields. At the college level, the Executive Committee of the Cooperative Study in General Education (4) provided helpful material for the evaluation of some of the less tangible outcomes of college education.

Engelhart (48) has summarized a series of suggestions to classroom teachers preparing multiple-choice tests for machine scoring. Much of the material is applicable to the improvement of any classroom test. Mosier, Myers, and Price (87) also presented numerous suggestions for improving multiple-choice items, including a list of criteria for checking such items. Diederich (32) described at some length the examination system in use in the University of Chicago's comprehensive examination program. In his judgment, factors which contributed to the satisfactory operation of the system included: (a) emphasis on problem-solving rather than fact questions; (b) the convention that only objectives agreed to by the teaching staff are covered by the examinations; and (c) the fact that students need not take an examination until they are ready. Various other writers who have discussed problems of test construction in specific fields are as follows: Sueltz (119) in arithmetic; Bowers (16) in industrial arts; Beckley (10) in retail selling; Barnett (7) in the social studies; and Meredith and Burr (84) in the area of intergroup education. Hendricks (65) reported on an effort to design paper-and-pencil tests for measuring important objectives in chemistry laboratory instruction. Validation against performance test results was reserved for later study.

Evaluation

Validity and Reliability of Tests

For discussion of aspects of reliability and validity which are primarily statistical or computational, reference should be made to the article by Travers (132) in the February 1946 REVIEW, and to chapter VII by Johnson and chapter VIII by Fattu in the present issue. The discussion here is limited to broad problems of validity and reliability, to studies of the validity of specific tests, and to evaluations of test technics in terms of reliability and validity.

Validity—In a comprehensive discussion of different kinds of "face validity," Mosier (86) pointed out that "validity by definition" (the test duplicates the criterion) is entirely sound in principle; but that such validity sometimes comes dangerously close, in practice, to "validity by assumption." Rulon (105) urged application of rigid standards to insure duplication between form and content of the test and the desired behavior. Tests so constructed could then be used to validate simpler, more practical instruments.

Dyer (41, 42) studied the validity of College Board placement tests in German and French, using grades in courses at different levels as the criterion. Validity coefficients ranged from .43 to .87 for the German courses, and were in the .80's in the French courses. In a study of the relationship of scores on a recall-type objective test in German to ratings of translations, assigned by highly experienced instructors, Dyer (40) obtained a validity coefficient of .64 based on 21 students. White (152), in a study of the validity of a test of achievement in high-school English, compared item analysis results on separate parts of the test with known differences in curriculum emphasis between two schools, and found that the differences were in accordance with expectation.

Reliability—Two attempts at a general formulation of the interrelationships of various methods of determining reliability appeared. Cronbach (27) evaluated six procedures in terms of the kinds of variances included in the estimate of error-variance used in determining reliability. He concluded that since no method is generally best, test authors should report more than one kind of reliability coefficient. He noted that the estimation of reliability generally involves making assumptions which the experimental conditions probably do not warrant.

R. L. Thorndike (126) made a detailed analysis of sources of variance in performance and evaluated ten possible procedures in determining reliability. His report drew upon the extensive experiences of the Army Air Forces Psychology Program. He stressed the importance, in the case of speeded tests, of obtaining test-retest reliability (by the separate administration of equivalent forms). He also pointed out that the determination of test reliability is sometimes inherently difficult or unsatisfactory; *viz.,* for tests involving insight, tests in which the subject has immediate knowledge of results, and performance tests in which sets of trials are run under conditions which vary appreciably (and generally uncontrollably) from set to set.

Reliability and Validity of Technics

Plumlee (96) has compared the relative value of three types of mathematics items at the college-entrance level; *viz.,* "demonstrative," "multiple-choice," and "answer-only." She concluded that the answer-only form was superior to the demonstrative form both in reliability (.92 *vs.* .75) and in predicting course grades (.44 *vs.* .37) for comparable testing time. She found that the multiple-choice and answer-only forms were about equally reliable and equally effective in predicting college marks. The multiple-choice form was, of course, more economical with respect to scoring. Huddleston (71), also working at the college-entrance level, found that an objective test of English grammar, correlated more highly with teacher's ratings on writing ability and with grades earned in English during the two years prior to the testing than did an essay test. Each test was of twenty minutes' duration. The Verbal section of the *Scholastic Aptitude Test* developed by the College Board correlated substantially better with both criteria than did the English tests. Good results from an objective test in predicting English grades were also obtained by Berg, Johnson, and Larsen (12).

Problems related to specific technics were also attacked in several other studies. Wesman and Bennett (151) did not find any advantage in the use of "none of these" as an alternative in multiple-choice items, altho they found some indications that this alternative tended to slow down response. Using item analysis procedures, Wesman (150) found that it was possible to identify correctly spelled words which have value as regular items (rather than merely as "filler") in a true-false spelling test. Wesman (148) also studied the relative merits of instructions to mark every item "right" or "wrong," as compared with marking only the wrong items, on a test of grammatical structure. No appreciable effect on reliability was found.

Interpretation of Test Scores

Flanagan (51) predicted that test norms would tend to place increasing emphasis upon socially meaningful statements about performance, along with the numerically expressed relative standings now emphasized. The development of such absolute standards should aid in the interpretation of test results by counselors and administrators. Such an approach implies empirical validation and the determination of critical scores in terms of extra-school standards.

Several articles dealt with technical points in the development of test norms. Thurstone (127) described briefly a procedure which he has long used in making scores on a new edition of a test comparable with scores on an older edition of the test, when the original standardization sample is no longer available. Harris (62) called attention to a common error in the interpretation of grade norms; namely the failure to keep in mind that zero attainment goes with a grade score of 1.0. Stein (115) described a test of homogeneity of variances, which should be used before combining results from different schools when determining local norms. Tucker (140) described a new system of norms for College Board foreign-language achievement tests. These norms were designed to achieve comparability from one foreign language to another, by taking into account the fact that the average amount of students' previous training varied from one language to another. Turnbull (141) found that it was not necessary to take into account the sequence of topics in physics courses in interpreting the performance of students on a college board physics achievement test taken two months before the end of the course.

Closely related to norms is the problem of score profiles. Walker (147) called attention to the need for a means of measuring the difference between two profiles in such a way that analysis of variance could be used to test agreement. Bennett (11) in a brief presentation argued that tests, before being used as separate entries in a profile, should meet a criterion developed by Kelley. Traxler (137) concluded on the basis of intercorrelations of part-scores that vocabulary, grammar, and reading scores on Cooperative Tests of foreign-language achievement are sufficiently different to justify separate consideration of each. In an experimental study covering two years, Tilton (128) attempted to change the relative position of arithmetic on the achievement test profile. He found that one of six groups studied showed a substantial relative gain; one showed a substantial relative loss.

Relevant to the problem of interpretation of student gains are studies by Woodrow (155) and Wesman (149). Woodrow investigated the intercorrelations of gains on Metropolitan and Stanford Achievement Tests for four elementary-school groups. For three of the groups, gains over a one-year interval were studied; for the other, gains over one-, two-, and three-year intervals. Altho three factors were tentatively identified in the gains, the intercorrelations were characteristically low, indicating that specific variance and error variance were conspicuously present in the gain scores. He also found that, except for one fourth-grade group, the correlations of gains with IQ were characteristically low. Wesman (149) using tenth- and eleventh-grade students, correlated gains in intelligence test scores with gains on achievement tests. The findings are in accord with the view that gain scores, particularly if the lapse of time has been relatively short, tend to yield low correlation coefficients.

A number of reports dealt with factors tending to obscure the interpretation of test performance. Of these, most significant was the review by Cronbach (26), in which he brought together numerous concepts under the general heading of "response sets" (tendency to gamble, speed *vs.* accuracy, and others). Within the field of achievement testing, response sets would presumably be most important in the less structured test situations (including essay tests), in true-false tests, and in tests where the same set of choices may apply to a whole series of items (e.g., true, probably true, uncertain, etc.). Cronbach offered a number of suggestions for minimizing the influence of response sets. Muntyan (89), in a study of retest performance, found that high-school seniors who repeated the same tests after a year did reliably better than a presumably comparable group of seniors taking the tests for the first time. When alternate forms of the test were used in the retest, only the physical science scores were reliably higher for the repeaters. Separate norms were recommended as a means of overcoming the difficulty. Studies of cheating were reported by Krueger (74) and Gross (60).

Relationships between achievement test scores and various other variables were included in several studies. Heston (67) studied the intercorrelations between scores on the *Graduate Record Examination Tests of General Education* and *Cooperative Achievement Test* scores. A factor analysis of the eight scores on the *Graduate Record Examination Tests* revealed a factor tentatively identified as "reading comprehension" with substantial loadings on all eight tests after rotation, and two other factors with relatively small loadings. Morgan (85) found that students with higher academic achievement within their grade were also on the average significantly higher in social acceptance and reputation among children in Grades V to VIII in a war-boom community. Gough (58) found only a slight positive correlation between socio-economic status and achievement, after IQ had been partialled out, among 127 sixth-grade pupils. Lobaugh (78) found that girls averaged somewhat higher on marks, while boys averaged somewhat higher on achievement tests; insufficient data were presented to evaluate the reliability or relative importance of the differences involved. Schreiber (109), using fifty-three cases, found no reliable gain in arithmetic computation during four years in high school; by contrast, spelling and language usage, literature, and hygiene showed marked gains during this period.

Evaluation of Technics for Testing

Vallance (143) undertook a comparison of essay-type and objective-type examinations with respect to their value as learning experiences. Contrary to earlier results in this area, he found that there was no evidence for the superiority of the essay test either as a learning experience or as a means of encouraging students to use a superior learning method in preparing for the test. Diederich (33), in a thoro discussion of the measurement of writing skill, pointed out that the correlation between two three-hour essay examinations written on different topics on the same day did not rise above .55. He argued that higher "reliability" in essay examination grades, if obtained by artificial devices, may lead to loss in validity. Diederich suggested that the efficiency of the essay examination for measurement of skill in writing may be increased by announcing, about a week before the examination, the reading passages upon which the composition will be based. Freeman (54) attacked the monopoly now held by objective tests; and indicated that tests should give more attention to requiring students to express thoughts in their own language. Sims (112) argued for the essay test from another viewpoint, stressing that the essay test gives valuable insights into personal-social development and processes of thought and judgment.

In an exploratory study, Courtney, Bucknam, and Durrell (24) compared written-recall, multiple-choice, and oral-recall coverage of the same material. This problem is worthy of further study, using large samples and varied subjectmatter. Another study which has a definite bearing upon test technic was reported by Davidson and Carroll (29). They found, by use of factor analysis and multiple correlation technics, that scores on time-limit tests of aptitudes frequently represented a mixture of knowledge or skill and speed of performance. Similar investigations are needed in the case of achievement tests.

A number of papers reported useful technics for achievement testing. Tinkelman (129) found that it was possible for judges to rate the relative difficulty of achievement test items in a particular field with satisfactory accuracy, but judgments of absolute difficulty were less useful. His findings imply that items can be arranged in an ascending order of difficulty with a reasonable degree of accuracy on tests which have not been pretested. Herfindahl (66) described two procedures for reading standard scores directly, using an International Test Scoring Machine. Taylor (125) outlined a number of shortcuts and technics for efficient use of the test scoring machine, and Bice (13) described a procedure for providing detailed knowledge of results to students on machine-scored answer sheets. Traxler (135) advocated overprinting of answer sheets to facilitate hand-scoring and to give students knowledge of their errors. In order to make copying difficult, Lemmon and DuBois (77) developed a procedure whereby students are required to answer questions printed in the same order in the test booklet on different spaces on their answer sheets. Ryans (107) described in detail a procedure for constructing a profile chart, using standard score conversions based on local data. Mosier and Price (88) presented a convenient system for arranging the alternatives of five-choice multiple-choice items in random order.

Applications

Planning the Testing Program

Findley (49) outlined a group testing program suitable for a modern school. Among other points related to achievement testing, he recommended: (a) that the tests be given in the fall to guide curriculum planning; (b) that careful cumulative records of results be kept; and (c) that in the first four grades measurement be based mainly on informal tests. Durost (38) outlined a minimum testing program, urging that achievement tests be used at the completion of each major phase of schooling, and that supplementary testing beyond the main program be provided for 10 to 15 percent of pupils. The Spring 1946 issue of *Educational and Psychological Measurement* carried descriptions by various authors of testing programs in a number of schools and colleges.

Counseling

Bordin and Bixler (14), on the basis of experience with the use of a procedure in which the counselor described the tests and allowed the client to express feelings in connection with the choice of tests, concluded that the technic had promise for increasing the guidance values of tests. They recommend that systematic research be undertaken to provide a more objective and comprehensive evaluation of possible effects. Traxler (134) expressed the view that achievement tests covering broad areas rather than tests in specific subjectmatter fields should be used for most counseling purposes. Diederich (34) described a program of remedial training in English built around the use of comprehensive examinations normally requiring three hours to complete. He reported that good results had been obtained by using recognition tests of writing ability in which students were required to choose among alternative ways of completing passages in actual student themes.

Teacher Efficiency

A number of pioneering investigations have used pupils' achievement-test gains as an index of teacher efficiency (8, 9, 21, 116). In the best studies, such variables as teacher-load, class size, class homogeneity, and socio-economic status of the groups are kept constant or are allowed for. Gain is measured as the difference between actual and expected gain. The expected gain for a pupil is the average gain for individuals who resemble that pupil in weighted score on a predictive composite; the predictive composite is made up of such elements as mental age, IQ, and scores on achievement tests at the beginning of the term. The statistical analyses utilize class averages rather than individual scores wherever appropriate to save computational labor. Finally, the design recognizes the possibility that a teacher may be more efficient with some kinds of pupils than with others (e.g., upper *vs.* lower halves of a class).

Results from the use of achievement tests in the measurement of teacher efficiency have so far been rather inconclusive, partly because the number of teachers studied has been relatively small. Sometimes the number of teachers in the sample has been little larger than the number of variables employed in the predictive composite. Another weakness is the lack of cross-validation (i.e., the use of a fresh sample, as a check against the capitalization of chance in the determination of regression weights and the multiple correlation coefficient).

It scarcely needs more than mention that achievement tests do not measure all the desirable products of teaching. Consequently, the application of achievement tests in the evaluation of teacher efficiency must be carried out with great caution and discrimination.

Research

Shannon (110), studying the role of various technics in educational research, found among other things that achievement tests were the most frequently occurring source of data in 1377 research studies published in the *Journal of Educational Research*. Among studies in which use of achievement tests in research produced results of general significance, the following may be briefly noted: Davenport and Remmers (28) found that average score on the Navy V-12 tests (which included aptitude as well as achievement material) for candidates from the various states correlated .63 with average teacher's salary and .80 with current average per pupil cost in the states. Mandell and Adkins (82) found that an interpretation-of-data test, of the type used in the Progressive Education Association Eight-Year Study, correlated well with standing of administrators in the federal government.

The desirability of using achievement tests as criteria for evaluating aptitude measures received some attention. Van Dusen (144) pointed out that the quality of realism obtained by measuring actual performance could not compensate for lack of reliability or fairness to all persons being measured. Stuit (117) gave two examples of situations in which the substitution of achievement test scores for informal ratings led to important shifts in validity coefficients of predictors.

Credit by Examination

Interest continued in the possibility of increasing educational efficiency thru the use of achievement tests for granting college credit. Pressey (97) pointed out that the current strain upon educational facilities may be eased by giving credit by examination. A. B. Garrett (56) indicated that sixteen years of experience with credit by examination in freshman chemistry at Ohio State University has led to satisfaction with the results. These tests are given to all students who have high-school credit in chemistry; from 5 to 15 percent are given credit for one-quarter's work in college chemistry. A booklet describing the achievement tests is sent to each student to aid him in reviewing. Programs in other colleges were described by Goetsch (57) and by Wickhem (153).

Tests of the United States Armed Forces Institute have received considerable attention. Detchen (30) provided a summary of information on the USAFI end-of-course tests, subject examinations, and *General Educational Developmental Tests*, including a list of thirty-seven references. Townsend (131) found that the *USAFI American History Test* correlated to the extent of .85 with the *Cooperative American History Test* (based on seventy-five cases); but that the intercorrelations of the parts were too high relative to the reliabilities to justify much use of the part scores.

Studies by Dyer (39), Bradley (17), and Callis and Wrenn (19) support the view that the *USAFI General Educational Development Tests* are excellent as predictors of college achievement. Dyer, Bradley, and Frandsen found low correlations between part scores and amount of college training in corresponding subjectmatter areas implying that these tests fall more nearly in the field of aptitude than of achievement. Frandsen (53) found that the *General Educational Development* natural science test scores correlated with computational and scientific interest as measured by the *Kuder Preference Record*, suggesting that the part scores may reflect interest as well as aptitude.

Dressel (35) presented a summary of how the *General Educational Development Tests* are used in the awarding of high-school diplomas. He noted that aside from mathematics, college courses no longer require fixed prerequisites in terms of high-school subjects. With respect to granting college credit on the basis of *General Educational Development Tests*, he reported a survey conducted by Barrows in which it was found that only about 10 percent of colleges are giving college credit to any extent on the basis of *General Educational Development* performance. Love (79) described the use of the *General Educational Development Test* in the College of Education at Ohio State University. Emphasis was placed on individualizing the use of the tests, with consideration being given to aptitude score before permitting the student to take the examination for credit.

Armed Services

Chambers (20), studying possible gains for education from armed services training, found that one outcome on which the majority of 258 educators with armed services experiences agreed was the desirability of more frequent use of achievement tests in civilian education. Tyler (142) considered the emphasis on continuous evaluation as one of six factors contributing to the effectiveness of military and naval training programs.

Several books describing armed services programs have devoted considerable attention to achievement testing activities. A general description of the achievement testing program of the Army Air Forces was presented by Flanagan (50). Hobbs (69) reported on a program of measurement using both printed and performance tests of flexible gunnery; in various studies, men were tested at all stages from basic school thru combat. Descriptions of the use of printed and performance tests in the Navy were presented in a volume edited by Stuit (118). The success of the armed services with performance testing suggests that this is a promising field for development. It should be noted, however, that the expense of this type of testing may well present a problem in civilian schools.

Large-Scale Testing Programs

A significant development in national testing programs was the preliminary report of the Committee on Testing appointed by the President of the Carnegie Foundation for the Advancement of Teaching (22). This committee expressed its belief that the unification of the large nonprofit testing agencies would benefit American education thru the elimination of overlapping effort and thru the availability of greater resources. In December 1947, the Educational Testing Service was incorporated, to bring together the testing activities of the American Council on Education, the College Entrance Examination Board, and the Carnegie Corporation and Foundation (46). The new organization is thus responsible, usually in cooperation with a sponsoring agency, for a number of large-scale national testing programs (47). Among these, achievement tests play a prominent role in: Entrance Examinations of the College Entrance Examination Board; Nation-wide High-School Testing Program; National Freshman Placement Testing Program; National College Sophomore Testing Program; College Chemistry Testing Program; Cooperative Achievement Tests; English Examination for Foreign Students; Engineering Achievement Tests; Graduate Record Examination; National Teacher Examination; and the Preliminary Actuarial Examinations.

Other testing programs of national scope, which place substantial stress on achievement testing are conducted by the Educational Records Bureau; the Project for the Selection of Personnel for Public Accounting (136), associated with the Educational Records Bureau; the Pharmaceutical Survey (100); and the testing program sponsored by the National League of Nursing Education (73). At the elementary level, the program for establishing norms on the *Metropolitan Achievement Tests*, in which pupils from every state were tested, may well be considered a national program (36).

Anderson (5) has described the Nation-Wide High-School Testing Program in which, during 1946, the *Cooperative Test of Recent Social and Scientific Developments* was given to about 143,000 high-school students in forty-three states. Vaughn (146) discussed the various projects of the Graduate Record Office, including the Inquiry into Postwar Conditions in American Colleges. In this program, forty liberal arts colleges administered to every graduating senior the *Graduate Record Examination Tests of General Education* and an appropriate advanced test in the field of specialization. Vaughn (145) also summarized the development of an achievement testing battery for engineering sophomores. Ryans (107) gave an account of the testing activities of the Committee on Teacher Examinations, and presented descriptive statistics on the 1947 examinations.

Among statewide programs, Smith (113) emphasized the role which testing had played in the activities of the Bureau of Cooperative Research and Field Service at Indiana University. Fox (52) described the rather comprehensive test services offered by Indiana University to schools in the state; detailed information is given on uses of tests, costs, available tests, and norms.

Current Needs in Measurement

Needs in measurement have been much discussed during this postwar period. A recurrent theme in these discussions is the need for testing to push into new fields, to develop new technics, and to exploit existing technics more thoroly. Adkins (2), Deutsch (31), F. S. Freeman (55), and Wrightstone (156) have suggested specific areas needing active exploration, among the most important of which are critical thinking, originality, and work-study skills. Brownell (18) urged that the appraisal of learning in research studies should stress: (a) the process of performance; (b) the retention of knowledge and skills, especially as measured by the relearning method; and (c) the transferability of learning. In the field of intergroup education, where the need for broadened objectives is perhaps most acute, Raths (98) criticized workers who sacrifice relevance for objectivity, and Taba (124) advocated that very extensive observational study be carried out before undertaking objective test construction.

A need for comparable tests and better norms to permit effective longitudinal studies and more satisfactory individual profiles has been stressed by Durost (37), Wrightstone (156), and Traxler (133). Various writers have expressed a need for a central agency to bring together and expand the stock of available information about tests, and to provide completely impartial advisory service to test users. The need for high standards of scholarship in constructing subjectmatter achievement tests has been indicated by Tolley (130); Palmer (94) and Packard (92) have questioned the scholarship of particular tests. Swenson (120) and Simpson (111) criticized the tendency toward hasty interpretation of standardized test results.

A related problem is one of time and budget. Lass and Wrightstone (75) in a survey of measurement in New York City secondary schools, and Painter and Painter (93) in a survey of forty-four college orientation testing programs, found that lack of adequate time, budget, and clerical help were serious hindrances. Conrad (23), while recognizing that "the individual is ever the source of original ideas," emphasized the need for coordinated institutional resources in the execution of research.

Trends

A number of writers stressed the importance of measuring general outcomes in terms of knowledge and skills, rather than in terms of time served or detailed course content. Thus, Learned (76) urged that large goals of study measured by suitable examinations replace the present course-credit system; Peik (95) predicted that the general education movement would facilitate such a change. Kaulfers (72) recommended that foreign-language testing be oriented around general goals of achievement of knowledge and skill. The *USAFI General Educational Development Tests* and the *Tests of General Education* developed by the Graduate Record Office may be considered efforts in this direction. Rulon (105) counseled moderation in applying the "generalized outcomes" approach, urging that the content area covered by a test should at least be recognizable. It would appear that the validation of such tests should include a check on the relative contribution of training and aptitude to score variance.

Better understanding of the organization of human aptitudes and abilities should lead to sounder and more efficient testing, as pointed out by Tolley (130). Wrightstone (156) noted a trend toward application of factor analysis to achievement testing problems. Guilford (61), in an article stressing aptitude testing but relevant also to achievement testing, predicted that test authors may presently be expected to report data on the factorial composition of new tests.

In his review of the testing movement from 1897 to 1947, Scates (108) noted that the full significance of the evaluation movement has not yet been realized. He pointed out that while measurement implies "moreness," evaluation implies "appropriateness," and that while measurement seeks simplicity and homogeneity, evaluation recognizes complexity and pays attention to the patterning of data. Megroth and Washburne (83) advocated, as a means of facilitating the measurement of intangibles, the development of a school atmosphere in which the pupil will not be afraid of being judged. Alpern (3) found that New York City academic high schools were using informal records of pupil behavior, along with the more formal cumulative record; several schools were collecting follow-up information about their graduates.

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CHAPTER VII

Recent Developments in Statistical Theory

PALMER O. JOHNSON

MUCH of statistical theory and methodology basic to the science of statistics is of recent date, appearing during the past twenty-five or thirty years. Close attention to and appreciation and understanding of the mathematical and logical foundations is necessary for the development of statistics. The basic research under development by the mathematical statistician provides the scientific capital from which fund the practical applications of statistical principles are drawn. There is wide variation among fields and among workers in any given field with respect to the appropriateness and efficiency of the statistical methods of analysis and designs of investigations used. It is hoped that this review may serve to make every research worker more critical of his practices.

Books

Two books making outstanding contributions to statistical theory and practice were published in 1946; Cramer's *Mathematical Methods of Statistics* (31) and Kendall's second volume of *The Advanced Theory of Statistics* (69). The former devotes twelve chapters to mathematical introduction comprised mainly of the theory of measure and integration supplemented by other mathematical theorems and tools to make the book mathematically self-contained for a reader with a good working knowledge of differential and integral calculus. The second part of the book contains the general theory of random variables and probability distributions. The main part of the book, entitled *Statistical Inference* is devoted to the theory of sampling distributions, statistical estimation, and tests of significance. The exposition thruout is mathematical in nature but is illustrated by numerous examples from several fields of application. The main emphasis of the theoretical presentation is on the determination of the precise conditions for the validity of the theorems, their connections with general probability and the logical relations among themselves. Kendall's Volume II supplements his earlier Volume I to form together a most comprehensive exposition of the theory of statistics. Four chapters on the theory of estimation, including one on the derivation of the properties of the maximum likelihood estimate, and a chapter each to Fisher's theory of fiducial probability and Neyman's theory of confidence intervals comprise the first section of the second volume. The main section of six chapters is devoted to the theory of statistical tests and treats tests of significance, the analysis of variance, the general theory of testing statistical hypotheses originated by Neyman and Pearson, and recently developed technics of multivariate analysis.

The remaining four chapters are on regression, the design of sampling inquiries, and time series. What the author terms the logical aspects of statistical inference are treated very forcefully in this volume. That is, he presents the broad principles on which inferences are drawn from statistical data in terms of probability. While this book does not attain the mathematical rigor of Cramer's treatment, it contributes both to those readers who are primarily interested in the advancement of research and to the practical statistician who, from its reading, will gain insight into the thinking and acting of the investigator when faced with the problems of planning and interpreting scientific inquiries. The somewhat detailed description of these two books serves to enumerate for the reader the principal problems of statistical science today.

Among other books published during the period, those written by Aitken (1), Hoel (56), Hogben (58), Kelley (68), Thompson (97), Thurstone (99), and the Statistical Research Group (27) may be pointed out for their general or special contribution to statistical theory and practice. A useful index of mathematical tables is now available (45).

Foundations of Statistical Theory and Method

The development of statistical theory and methodology as an exact science is founded in mathematical probability. The conceptual model constructed to deal with statistical data is grounded on probability theory. The axioms and the structure of theorems based on them make up the subject of mathematical theory. The various ways of choosing axioms have led to different formulations of the theory of probability.

The chief function of statistics in scientific research is in the role of drawing statistical inferences, the process by which new scientific knowledge comes into being. The two problems of statistical inference are: (a) the problem of testing statistical hypotheses and (b) the problem of estimation.

The theory of the design of experiments has as its purpose the development of principles applicable to the collection of primary data in such a way that valid inferences can be drawn from them and for eliciting the greatest amount of information latent in the data in the most efficient way.

Quite the most fundamental problem in practical statistics is the sampling problem. The developments occurring in the design and analysis of experiments have been of special significance in sampling theory and practice.

This delineation of the subjectmatter of statistical science in terms of its major purposes and procedures serves as the basis of classification of the studies reviewed. Some of the studies contribute to several of the areas, but each is placed in that category to which, in the opinion of the reviewer, it contributes most directly.

Probability Theory

The rapid development of statistics went forward with striking increases in the number and the significance of its diverse applications in many fields. The rapid exploration of new domains left numerous gaps in the theoretical foundations. However, at present and for some time in the past there are increasing numbers of investigations contributing to a more and more rigorous theoretical structure. The firm grounding of statistics in probability theory and the significant contributions in this field are clearly demonstrated in the very comprehensive survey of problems restricted to the purely mathematical aspects of the subject presented by Cramer (32). Modern statistical inference stems from the classical limit theorem of probability. Two fundamental papers dealt with this topic. Feller (39) explained the mathematical content and the meaning of the two most significant limit theorems in the modern theory of probability: (a) the central limit theorem and (b) the law of the iterated logarithm. Erdos and Kac (38) proved four important limit theorems of the theory of probability.

Hsu (60) studied the approximate distribution of ratios of the following two types: (1) $\frac{Y}{X}$ and (2) $\frac{Y}{X}$. A knowledge of the probability distributions of ratios has special significance in education and psychology where quotients are frequently used as statistics, for example, the intelligence quotient. It is also important in experimental work to be able to set up the true average of the experimental group as a fraction of the true average of the control group. In this case, what is needed are the fiducial limits of a ratio. The procedure in setting up fiducial limits of a ratio between quantities having normally distributed estimates has been given by R. A. Fisher in his book, *The Design of Experiments* (Fourth Edition).

Other contributions to distribution theory were made by Aroian (6) concerning the probability function of the product of two normally distributed variables, by Hsu (62) on the asymptotic distributions of certain statistics, by Camp (23) on the effect on a distribution function of small changes in the population function, by Chung (24) on the maximum partial sum of independent random variables, and by Bhattacharyya (15) dealing with the distribution of the sum of Chi-squares. Bartlett (9) showed that orthodox probability theory may be extended to include probability numbers outside the conventional range.

Sampling Theory

While it can be stated broadly that no essentially new methods of selecting representative samples have been developed in recent years, many additions to our knowledge of underlying theory of the various methods of sampling have been made. Furthermore, much development has taken place in technics for estimating the sampling errors of both simple and complicated sampling designs. Yates (115) published a very comprehensive and informative paper dealing with the developments and applications to problems in area sampling and in economic and social surveys. The intensive use of sampling during the war both in economic and social surveys, and in operational research led to development of methods of sampling for handling materials at times varying greatly from part to part and of methods of estimating sampling errors when sampling units of widely different sizes were used. However, when the discrepancies in size are marked, estimates established on ratios or percents are generally required, which of necessity complicates the estimation of the errors of sampling. Random sampling (without restrictions), stratified sampling (random sampling from groups), subsampling, stratification for two or more factors, and balancing are the principal sampling methods used. All these methods involve random selection of the sampling units and thereby provide exact estimates of sampling error. The analysis of variance, which makes possible the collating of estimates of error and the separation of components of error not strictly homogeneous, has provided the basis for development of the various systematic methods of sampling. The principle of randomization which made possible the development of the various modern designs of experiments correspondingly made possible the development of the relatively complicated schemes of sampling by providing a valid estimate of error in virtue of the random elements in the process of selecting the sample.

A good illustration of the modern theory and practice of sample designs was presented in *A Chapter on Population Sampling* (103). This monograph by the Bureau of the Census Sampling Staff deals mainly with the theory underlying a particular approach to areal sampling with subsampling and demonstrates the use of the "principle of optimum allocation by which the smallest sampling error is obtained for a specified expenditure." Formulas were developed for estimating the total population, the variance of this estimate in terms of population parameter, expectations of the sample variances, and approximations to these expectations. Other illustrations of the problems and methods of sampling surveys were given by Hansen, Hurwitz, and Gurney (54), Hansen and Hauser (53), Jessen (64), and Mahalanobis (75).

Cochran (25), studied the relative accuracy of systematic and stratified random sampling in a type of population in which the variance within a group of elements increases steadily as the size of the group increases. The stratified random sample was found to be always at least as accurate on the average as the random sample with its relative efficiency represented by a monotonic increasing function of sample size. No general result was found valid for the relative efficiency of the systematic sample. Systematic sampling in certain populations of the class of populations specified was more precise than stratified sampling for one sampling rate, but was less accurate than random sampling for a different sampling rate. However, when the correlogram was in addition concave upwards, the systematic sample was on the average more accurate than the stratified sample irrespective of sample size. Other comparative studies of sampling methods were made by Madow (74) and by Brown (22).

Gumbel (49) studied the conditions of independence of the extremes in a sample. Thurstone (98) considered the theory of univariate and multivariate selection in factor analysis, making a comparison of the psychological interpretations of the resulting factors. Baer (7) contributed to the problem of sampling from a changing population. Cases arise where it is not possible to take more than one sample at any given time and if the population changes between successive samples, the problem arises of estimating from a random sampling of the original population certain parameters of a family of populations. The stochastic limits for the mean, variance, and certain other statistics of the sample were determined. Molina (78) presented a method of analysis and presentation for use in estimating a population fraction from a sample fraction, which utilizes both statistical data and collateral information.

To the great fundamental advances in the theory and technics of sampling, most workers in educational and psychological research seem to remain completely indifferent. Only two publications bearing on sampling problems in these fields were located. Cornell (29) applied the method of stratified sampling to a survey of higher education enrolment for the purpose of securing an unbiased estimate of the total enrolments of various types of students in six major classes of higher educational institutions. Marks (77) pointed out that it was difficult to find any study in psychological research that used sampling designs which made possible the valid estimate of sampling error. He used the description of the sampling methods in the revision of the Stanford-Binet Scale to illustrate how the design could not yield statistics with measurable standard errors. Marks also treated the technical problem of cluster sampling in psychological research showing how cluster sampling almost always increases sampling error as compared with unrestricted sampling error of the same number of cases. This is attributable to the practice of sampling previously existing groups of the population which involves a positive intraclass correlation of the variable under investigation. Since cluster sampling is an extremely valuable method of sampling in psychological research it is essential to know the conditions and means by which statistical estimates and the measures of their sampling error may be accurately made.

The need is urgent for thoro studies of the efficiency of different sampling procedures for the different types of problems in educational research.

Test of Statistical Hypotheses

Suppose that a random variable X is the measurement of a certain character and that a number of repeated measurements are carried out, say N times. We then secure N random variables: X_1, X_2, ———, X_N. It is assumed that the N random variables are independently distributed and the set of values comprises a sample of N independent observations on X. Assume that the probability distribution of X is normal but that the values of some parameters, Θ_1, ———, Θ_q specifying the population are unknown. Any assumption about the unknown parameters, Θ_1, ———, Θ_q may be called a statistical hypothesis. Situations are often met in research in which hypotheses are advanced regarding the properties of the probability distributions of certain variables and we wish to test whether available statistical data are compatible with the hypotheses or not. A test of this general character is called a test of significance relative to the hypothesis under consideration. The hypothesis that chance factors may have given rise to an observed effect is frequently called the null hypothesis, an hypothesis which is encountered in a number of different forms in research or statistical work. As mentioned earlier the testing of statistical hypotheses is one of the fundamental problems of statistical inference. The studies dealing with this problem are presented in five categories.

General theory of testing statistical hypotheses—Fisher (43) discussed the process of reasoning involved in using observations as a basis for making probability statements about parameters, the knowledge about which is derived only from such observations. In contrast to his interpretation of statistical tests there is the interpretation built on the frequency concept that the level of significance in significance tests is equal to the frequency with which the hypothesis under test is rejected in repeated sampling of any fixed population permissible by hypothesis. The latter interpretation is basic in the Neyman and Pearson approach in dealing with tests of statistical hypotheses. Pearson (83) presented as an illustration of this interpretation the problem of testing the significance of a difference between two proportions in a 2 X 2 table. There may be two possible outcomes of a test of an hypothesis, H_o; either the hypothesis is rejected or it is accepted. Since there are two different actions with respect to testing H_o, there are two different kinds of errors of judgment: (a) errors of the first kind consist in an unjust rejection of H_o, and (b) errors of the second kind consisting in the failure to reject H_o when, in fact, it is incorrect; that is, when some alternative hypothesis is true. To know the properties of a statistical test is to know the probabilities of the two kinds of error that may be committed in the application of the test. The property of the test associated with the control of the second type of error is designated as the power of the test. The power function is also of great value in comparing the relative merits of alternative tests of the same hypothesis. Hsu (61) dealt with the power function of the E^2-test and the T^2-test. Johnson and Hoyt (65) extended the utility of the Johnson-Neyman concept of the "region of significance" by formulating the theoretical basis and illustrating useful results for a three-dimensional region. Welch (108) generalized "student's" problems to include the case of testing the significance of the difference of means of populations with unequal variances. Wilks (112) developed test criteria by the Neyman-Pearson method of likelihood ratios for testing simultaneously the equality of means, equality of variances, and equality of covariances in a normal multivariate population of K variables on the basis of a sample. An application of these criteria was made in testing the hypothesis that three "parallel forms" of a test are really parallel forms as far as means, variances, and covariances are the same. Grant (47) illustrated the use of certain statistical tests, including the criteria of randomness, in learning and problem solutions in experiments in psychology. Johnson and Tsao (66) developed a test of the homogeneity of a set of variances when correlation exists between the means and standard deviations. This test is of special value in analyzing the effect of increasing age on variability of traits. David (35) developed a Chi-square, smooth test for goodness of fit which takes into account the sign of the deviations of observations from hypothesis and the order of these signs.

Other studies treated the test of significance for intraclass correlation when family sizes are unequal (14), the use of the range in the t-test (73), the use of ranking methods in testing the significance of differences in individual comparisons (111), operating characteristics (40), the use of the statistical sign test based on the differences between pairs of observations, with a table of significance levels (36), the principle of likelihood for testing a broad class of statistical hypotheses (59), the significance of trend differences (73), and the effect of intraclass correlation on certain significance tests (107). Useful tables have been prepared which provide the means of making the most efficient test now available for testing the homogeneity of a set of estimated variances (96).

Sequential tests—An important extension of the Neyman and Pearson ideas on testing hypotheses was evolved by Wald (106) and his associates (27). The method of sequential tests of a statistical hypothesis applied, as yet, principally to the analysis of industrial products consists in the application of a sequential probability ratio to the observations taken one at a time. After each observation one of the following actions is taken: (a) the lot or process under examination, or the statistical hypothesis under test, is accepted, (b) it is rejected, (c) judgment is suspended and another observation is taken. In cases (a) and (b) no further observation is taken. The claim made for this test, where it is applicable, as against the classical tests, which use a sample number fixed in advance of the experiment, is that it can satisfy the conditions of the test with a smaller average sample size often as much as 50 percent less. Sequential procedures are based upon conditions of randomization or where the sequence of the results upon inspecting the items is a random sequence. The actual procedures in conducting the experiment determine the test to be used. It is worthy of note that in this process the role of statistical analysis is in the very process of experimentation itself as compared with its consideration at the time of designing the experiment, characteristic of modern experimental designs.

A special case of sequential analysis was treated by Stein (94), who developed a two-sample test of a linear hypothesis, the power of which is independent of the variance. Cowden (30) provided an illustration of the application of sequential sampling in testing the achievement of students in a class in statistics.

Rank correlation—Since rank correlation is a useful technic for the analysis of certain kinds of data arising in educational research, investigations of this technic are of importance to educational research workers. An increasing amount of attention is being given to problems of statistical inference which are referred to as nonparameter problems; that is, problems in which the cumulative distribution function of the population may be held to be continuous but in which the function is arbitrary within a broad class. In these problems, ordered statistics (ranked sets of values in a random sample from lowest to highest values) come into prominent use. The rank-correlation coefficient is an example of a nonparametric test for two dimensions, based on the method of randomization.

Daniels and Kendall (34) considered the problem of setting up confidence intervals for a rank-correlation coefficient in a correlated population and developed a test of significance for the difference between two rank-correlation coefficients. Hoffding (57) showed that the sampling distribution of Kendall's (1938) measure of rank correlation, τ, tends to normality as $n \infty$ for any population with continuously distributed X and Y if a certain condition holds. Sillitto (92) treated the problem of the probability distribution of Kendall's τ for cases in which ties occur in one of the two rankings. He also constructed a table for use in showing the probability of attaining or exceeding an observed score value (*S*) by chance where paired or triplet ties occur. Whitefield (110) built upon the results of Kendall (70) in treating the case of tied rankings to the determination of the relation between two variables one expressed as a ranking and the other as a dichotomy. This problem is often encountered in determining the relationship of a psychological measurement and an external criterion.

Analysis of variance and covariance—The analysis of variance technic developed by R. A. Fisher twenty-five years ago in connection with certain experimental designs in agriculture is the principal research tool of the biologist and is being increasingly used in the physical sciences, in engineering, and in the social sciences. Apparently its great powers are just beginning to be exploited. The principal purposes of the analysis of variance are: (a) to obtain efficient estimates of certain treatment differences of interest to the experimenter, (b) to obtain a measure of the degree of confidence to be placed in the obtained estimates by means of estimated standard errors, fiducial limits, or confidence intervals, (c) to carry out tests of significance that are valid and sensitive. For the intelligent and efficient use of any statistical tool the research worker needs to know the assumptions underlying their proper use and how to test them. The conditions have not often been made clear in the textbooks or manuals, and it is not often that reports of researches employing analysis of variance procedures have provided any evidence as to whether or not their use was justified in the particular situation. Three useful papers, recently published, have dealt with the conditions underlying the efficient use of the analysis of variance technic. Eisenhart (37) enumerated the several assumptions underlying the analysis of variance and treated the practical importance of each. Cochran (26) pointed out the consequences when certain assumptions are not satisfied and gave important information on means of detecting the failure of the assumptions as well as on how to avoid the more serious consequences. Bartlett (10) treated the problem of transforming the original data by changing the scale of measurement in order to make statistical analysis more valid. He gave particular consideration to the use of transformations, such as the square root, the logarithmic, and the inverse sine transformation in applications of analysis of variance. Another important paper by Bartlett and Kendall (11) dealt with the logarithmic transformation in analyzing heterogeneous variances. Irwin (63) treated the problem of interpreting the within and between class analysis of variance when the intraclass correlation is negative.

The use of the analysis of variance would be greatly limited, particularly in education and in the social sciences generally, if, as was the original case, equal or proportionate numbers of observations were required in the subclasses. Several important recent papers have dealt with the problem of unequal representation. Tsao (101) provided a mathematical solution for the general problem of the analysis of variance and covariance where there is unequal representation in the subclasses. He also presented certain approximate methods of practical use to research workers. Other contributions to this problem were made by Ansbacher and Mather (5), by Baten (12), by Hazel (55), by Patterson (82), and Tsao and Johnson (102).

Fisher (44) gave a simple solution by the analysis of covariance method to the often puzzling problem of the relation between a part and the whole. Finney (41) showed how the precision of mean comparisons can often be increased by the application of analysis of covariance.

Multivariate analysis—Modern multivariate statistical theory has given rise to new exact tests of statistical hypotheses in terms of probability, which may involve extensive multiple measurements. In 1936 Fisher introduced the discriminant function by which can be solved the problem of specifying an individual as a member of one of many populations or the classification of a number of populations based on the configuration of various characteristics. Mahalanobis' generalized distance function, D^2, can be used to measure the "distance" between sets of multiple measurements, for instance, to determine whether any two members of a constellation are closer to one another than any two belonging to different constellations. Hotelling's generalized "Student's Ratio" is a powerful tool for the discrimination of mean values between multivariate normal populations (on the hypothesis of equal variances and equal covariances). Contributions to the theoretical or practical solution of problems in this area were made by Von Mises (105), Radhakrishna (89), Bose (19), Yardi (114), and Beall (13).

The noncentral Wishart distribution is the joint distribution of the sum of squares and crossproducts of the deviations from the sample means when the observational values originate from a set of normal multivariate populations with stabile covariance matrix but with expected values varying from observation to observation. This distribution is the basis of obtaining the power function for many statistical tests in multivariate normal statistics. Anderson (4) applied the noncentral distribution to obtain the moments of the generalized variance and the moments of the criterion for linear hypotheses when the population means lie on a line or a plane. Guttman (50) evolved a new approach to paired comparison and rank order.

Other theoretical or applied problems involving multivariate analysis were presented by Jones (67), Tintner (100), Wherry and Taylor (109), Bittner (17), and Brogden (21).

Theory of Statistical Estimation

The problem of estimation is one of the cornerstones of statistical theory. The theory of statistical estimation treats the problem of estimating values (statistics) of the unknown parameters of distribution functions of specified mathematical form from random samples assumed to have been taken from such populations. The most important general method of estimation is the method of maximum likelihood. Interval estimation is given either by fiducial limits or confidence intervals. Halmos (52) discussed a necessary and sufficient condition for the existence of an unbiased estimate and illustrated by application to the moments of a distribution. Bhattacharyya (16) attempted to find a lower bound of variances of estimates of a given function of the parameters which is independent of the estimates used. Vatnsdal (104) found the position of the point about which the variance of the second and of the third moments is a minimum. Smith (93) contributed to the theory of estimating linear functions of cell proportions. Pillai (84) studied different methods of setting up the confidence limits for the correlation coefficient. Girshick, Mosteller, and Savage (46) presented some theorems with applications dealing with unbiased estimation of the parameter P (fraction defective) for samples drawn from a binomial distribution. Two studies (8, 48) dealt with relations between range and standard deviation. Aiken (2) derived linear approximations by least squares making use of the properties of the variance matrix. Winsor (113) developed a general principle that when possible the experiment should be designed so that the desired regression function can be determined directly; where this is not possible the inverted regression should be used.

Mosteller (80) proposed a number of statistical technics for the economical analysis of large masses of data by means of punched-card equipment. The principal technic is the use of functions of order statistics which promises to provide a simple and effective practical method for estimating parameters of normal and other populations which have a continuous cumulative distribution function. Scheffe and Tukey (91) validated the existing solutions in the nonparametric case for setting up confidence intervals for an unknown quantile and population tolerance limits. The assumption involved only a continuous cumulative distribution function.

The analysis of variance technic has been used chiefly in making tests of significance. Another significant use, not very well known, is in dealing with problems of estimation, that is, in the detection and estimation of components of random variation associated with a composite population (37). In problems of this kind the parameters involved are variances, the absolute and relative magnitudes of which are of chief importance. Crump (33) has treated very thoroly the problems involved in this use of the analysis of variance technic. Satterthwaite (90) developed an approximate distribution of the estimate of variance components, based on the Chi-square distribution.

Stevens (95) discussed scales of measurement with special consideration to psychological measurement under three phases: (a) the various rules for the assignment of number, (b) the mathematical properties (or group structure) of the resulting scales, and (c) the statistical operations appropriate to measurements performed with each scale type. Cornell (28) discussed the characteristics of the major types of apportionment formulas. Mann (76) treated a problem of estimation occurring in public-opinion polls. He showed that the variance of the estimate in public-opinion polls is somewhat larger than the variance in random sampling because a cluster and not a random sample is used.

Design and Analysis of Statistical Investigations

The principles of the design of experiments were laid down by R. A. Fisher, and by 1926 the essentials of good experimental design and analysis were determined: replication, randomization, and control of variability. The analysis of variance technic was a simultaneous development. This technic supplies the appropriate method of estimating the experimental error and of carrying out the exact tests of significance. It is a commonly accepted statistical principle that the valid interpretation of a body of data requires a knowledge of how the data were obtained. Equally it is understood by the modern research worker that the conclusions drawn from experimental results must be based on a knowledge of experimental principles at all stages of an experiment. The most efficient method of analysis can be employed and the greatest precision secured only if the experiment is planned with this end in view. The principles laid down by Fisher have stood the test of time and are being used successfully in most experimental sciences. There has been some change in emphasis during the last two decades away from a tendency to overemphasize the importance of tests of significance to more emphasis on the estimates of the effects of treatments and the measurement of their experimental errors. There have been new types of design developed many of which are connected with factorial design, which design includes all combinations of a set of factors in the same experiment.

In spite of these developments the prototype of educational experiments is the single factor experiment presumably based on the doctrinaire theory that an experiment must be simple and apply the so-called "law of the single variable." The modern principles of experimental design would be of special importance in large-scale cooperative experiments so much needed in education. The importance of planning is clearly indicated in the case of experiments or other observational programs, such as longitudinal studies running over periods of years. Major changes in such investigations are usually impossible after they are underway and serious mistakes in designs would necessitate the scrapping of the whole investigation.

Space permits only a few studies dealing with experimental design and analysis to be reported. Nandi (81) considered the problem of estimating linear functions of unknown parameters and testing various hypotheses relating to them. He gave the analysis of variance of Split-Plot and Strip-Arrangement Designs showing that the estimates of experimental errors were different according to the hypotheses tested about different sets of parameters. Bose (20) formulated methods of attacking the problems of balancing and partial confounding and illustrated the actual working out of these processes. He also generalized certain recent results of Fisher with respect to the maximum number of factors that can be accommodated in a symmetrical factorial experiment subject to the conditions that no main effect or two factor interaction is confounded. Kishen (71) provided a comprehensive general solution for the design of experiments for weighing and making other types of measurements. Plackett and Burman (86) worked out the designs for optimum multifactorial experiments in physical or industrial research. Plackett (85) educed certain generalizations in multifactorial designs. Anderson (3) reviewed the various contributions that have been made to the problem of missing-plot technics and derived some formulas for missing plots in split-plot experiments by minimizing the error variance. There is considerable need in educational research for developing technics for handling the many situations, which arise where data are incomplete for certain experimental subjects. Haldane (51) presented certain simple designs based on logical rather than experimental principles for the study of the interaction of nature and nurture which is one of the main problems in genetics.

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CHAPTER VIII

Computational Technics

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THE flood of computational demands brought on by the war quickly swamped available equipment and computers and lent considerable impetus to the development of more rapid computational devices. War-time restrictions kept information about these devices out of circulation until recently, but in 1947 a host of articles began appearing in engineering and applied science journals, and in October 1947 the journal *Mathematical Tables and Other Aids to Computation* began a new indexing section, "Automatic Computing Machinery."

Material published during the past three years on computational technics may be classified in terms of its relation to: high-speed automatic computers, mechanical computers, tabular and graphical devices and variations in formulas and technics. Most of these devices and changes, except the automatic computers, are familiar to educational research workers.

General Bibliographies

Besides the indexes available in educational and psychological journals, bibliographies and summaries may be found in Clark (27); George (55); Murray (108); the Fletcher, Miller, and Rosenhead index (51); and the Harvard Computation Laboratory Manual (75); in the *Journal of the American Statistical Association*, "Statistical Methodology Index" (22); the *British Journal of Psychology*, "Statistical Section"; *Mathematical Reviews*; *Mathematical Tables and Other Aids to Computation*; and the International Business Machines Corporation *Bibliography* (81).

High-Speed Automatic Computers

New mechanical and electronic computers, developed since 1942 largely under the pressure of the war, handle information with great speed and skill no matter how long the routine may be. Two differences may be observed between these machines and conventional equipment: (a) data and the entire routine for solving a problem are put into the device and it automatically carries out the operations printing the answers as it obtains them, (b) information can be transferred automatically from any part of the machine to any other part. For example, the machine can be fed tables required for certain sequences in the calculation, and at the proper times the device will almost instantly refer to the required entry and use it in solving the problem. General discussions of these machines were published by Alt (2, 4), Archibald (6), Berkeley (13), Burks, Goldstine, and Von Neumann (21), Comrie (29), Duncan (41), Hartree (66, 68, 69), Peterson and Concordia (112), and Stibitz (121, 122).

At least five types of automatic computers were in operation during the war: the Bush Differential Analyzer, the Electronic Numerical Integrator and Computer (ENIAC), the IBM Automatic Sequence Controlled Calculator, the Bell Telephone Laboratories Relay Computer, and the Electronic Discrete Variable Computer (EDVAC).

The Differential Analyzer (5, 13, 23, 67, 112) produced under the direction of Vannevar Bush handles with uncanny accuracy addition, subtraction, multiplication, division, integration, and the like as continuous operations by means of eighteen integrating devices and 130 mechanically coupled rotating shafts. Initial values and instructions are fed into the machine as punched holes on a paper tape, and answers come out typed by electric typewriters and/or as graphs. It performs integrations directly, works differential equations which cannot be solved by direct means, and gives numerical answers rapidly to five-decimal place accuracy.

The Sequence Controlled Calculator (1, 13, 66, 67) was constructed thru the cooperative efforts of IBM engineers and Professor Aiken of Harvard. A series of ten-position relays, similar to counter wheels, handle the digits zero to nine. The counter positions are connected in banks of twenty-four so that numbers of twenty-three digits can be handled. Numbers go into the machine by feeding punched cards, setting hand switches, or as tables punched on long paper tapes. Instructions are put in as a long sequence of rows of punched holes on an endless paper tape called the sequence control tape. Results come out punched on cards or typed by electric typewriters. The Harvard Computation Laboratory *Manual* (75) gives instructions for coding data for the machine.

The ENIAC (4, 13, 56, 66, 68, 109) represents digits by pairs of rows of ten vacuum tubes each. In one row of the pair a tube corresponding to the digit recorded is turned on. In the other row all the tubes are turned on except the one corresponding to the recorded digit. To add unity a single impulse is sent thru which extinguishes the lighted tube in the first row and lights the next tube. Other numbers are added by sending impulses thru repeatedly. Impulses may be sent at the rate of 100,000 per second. The numbers handled are of ten-decimal places. Additions are made at 5000 per second, and multiplications at 350 per second. Numbers go in by direct setting of switches or by feeding cards. Results come out punched on cards. Instructions are put in by plugging in and connecting tubes—a slow and tedious process. Once plugged in the ENIAC works so fast that it can compute the trajectory of a projectile faster than the shell itself can travel thru the air (13).

In the Bell Telephone Laboratories Relay Calculator (2, 13, 21, 121, 122) two-position relays are used to represent numbers. Five open and two closed relays represent each digit. Decimal numbers are put into the machine in binary form. The machine is extremely flexible and dependable, and complicated routines are readily handled. Besides handling the four fundamental processes, it can consult any of six tables of 1000 numbers each; it can remember thirty numbers of seven digits each and their decimal points; it can refer to any of twenty-five routines; it can record results on paper tape and later in the same problem use them in further calculations. Altho this is the slowest of the machines discussed, it is estimated that a single machine can do the work of about 100 human computers.

In order to combine the flexibility and accuracy of the Bell Relay Computer and the speed of the ENIAC, the EDVAC was developed (4). Only sketchy information has been published up to this time on the EDVAC.

Womersley (142) and Berkeley (13) have emphasized that in order to make efficient use of these machines a new type of thinking is needed. Formulas and procedures selected for the ease with which they could be applied to pencil-paper computing are no longer adequate. Suggestions of such changes appear in the Harvard *Manual* (75). An interesting development in this connection is the use of "flow diagrams" described by Goldstine and Von Neumann (57). These "flow diagrams" emphasize the logical aspects of the problem and subordinate the purely arithmetical. After completion of a "flow diagram," the actual coding is fairly easy, tho tedious.

Comrie (30) and Hartley (64) have recognized that these machines are extraordinary devices, but have also observed that their cost and complicated routine of coding data and instructions make them useful only for problems involving huge masses of data and intricate routines of computation. For most practical purposes the burden of computation must be carried by conventional mechanical devices as it was during the war.

Mechanical Computers

Punched card equipment, mechanical accounting machines, and the various kinds of desk calculators comprise the mechanical calculators. Bibliographies may be found in Murray (108), George (55), and in the International Business Machines Corporation *Bibliography* (81).

Most of the applications reported in the literature surveyed were concerned with punched card equipment. Especially prominent was the large number of applications in engineering and applied sciences probably forced upon workers in these areas by wartime demands. Herget (72) used a tabulator and multiplying punch to describe the equation of motion of an n-body problem. Bergman (11, 12) used punched card equipment to solve differential equations; Munk (107), Leppert (96), Kormes and Kormes (89) indicated aeronautical applications; Cox, Gross, and Jeffrey (33) illustrated applications in crystallographic analysis; Eckert (45) and Frear (52) described applications in chemistry.

The printing of mathematical tables was further discussed by Eckert and Haupt (46). Laderman and Abramovitz (93) described the use of tabulating equipment in differencing tables, and then pointed out that in the U. S. Hydrographic Office Mathematical Tables Project the Sunstrand

Accounting Machine, Model D, was used. It efficiently checked the accuracy of tables by differencing and it also could reverse the operation to construct tables from differences. Reynolds (114) used a prepunched master deck in constructing tables which involved extracting numerous square roots.

Grosch (60) described a method of harmonic analysis by use of progressive digiting. Alt (3) delineated the method developed at the Aberdeen Ballistic Research Laboratory for multiplying matrices by using punched cards. He also described the set-up for finding the inverse of a matrix by successive approximations. Kimball (87, 88) listed some punched card computational methods used by the Census Bureau, and Kempthorne (85, 86) indicated the uses of a punched card system for survey data.

Advantages and disadvantages of multiple punching were summarized by Benjamin (10) who also suggested efficient means of coding and wiring to extract information. Taylor (127) described the use of an alphabetic punch in conjunction with coded step intervals to increase the amount of data punched on a card. He suggested the resolution of two difficulties, (a) separating the zone from the numerical punches, and (b) distinguishing between the *X* and the *Y* punch in tabulating. Bartlett (9) reported a process for listing scattergrams.

Ellis and Riopelle (47) used a sorter, alphabetic tabulator, a collator with a card counting device, and a summary gang punch to compute higher moments as well as sums, sums of square, and crossproducts. Dwyer (42) reported formulas and procedure for correlation coefficient summation when there were missing variates. To eliminate information in other fields corresponding to the missing variate, the method used was an elimination field and *X* distributors when the missing information was punched *X*, or digit selectors when the missing information was not punched.

Tucker (134) described in detail a simplified punched card method in factor analysis which required only a limited amount of equipment, i.e., a key punch, an alphabetic accounting machine with either complete progressive totals or a summary punch, and counters that both add and subtract. An illustrative example was worked out, including complete operating instructions and machine set-up. The iterative trial procedure rather than the sign change method was used.

Mosier (105) described the use of IBM accounting equipment in carrying out an iterative procedure for arriving at weights for a set of questionnaire responses. The problem involved scaling 100 items on a housing inventory so that weights assigned would yield the most reliable over-all index. Weights were assigned arbitrarily and then adjusted by successive iterations. Three iterations were sufficient in the example reported. Kurtz (92) used data from life insurance agents' rating charts punched on IBM cards to determine how to score the various items of information to yield the maximum correlation with sales and persistence. Other useful applications of punch card equipment are reported by Cochran (28), McQuitty (101), Dyer (44), and Homeyer, Clem, and Federer (74).

Berkeley (13) indicated how written information might be put into punch card form, and Gull (61) illustrated a punched card system for bibliography and indexing of chemical literature. Black and Olds (17) described how detailed tables of census data might be made available to users at a minimum cost.

The use of punched cards was also discussed by the International Business Machines Corporation publications (77, 78, 79, 80).

Calculations made directly from test scoring machines were discussed by Froehlich and Keller (53) and by Herfindahl (71). Epstein (48) reported on statistical analysis with hand punched and sorted cards. While these are interesting applications, the use of punched cards in handling the same problems seems to be more efficient and far more flexible.

Various kinds of mechanical calculating machines were also discussed. The construction of calculating machines was comprehensively treated by Murray (108). He considered digital machines and the component parts of desk calculators, continuous operators, composite analogue devices such as differential analyzers, network analyzers, linear equation solvers, and mathematical instruments such as planimeters, harmonic analyzers, and the like. The book, however, contained nothing on large-scale discrete variable calculators. Berry and Pemberton (15) described a twelve-equation computing instrument, Bleik (18) reported on a machine for solving quadratic and cubic equations, and Zuse (146) designed a rapid but in several respects impractical computer.

Sadler (115) and Comrie (30) expressed the belief that full exploitation of the capabilities of the commercial calculating machines was usually the most efficient way of dealing with ordinary problems. The coupling of two or more machines together, with automatic transfer of results from one to the other, produces a considerable increase of efficiency. Comrie discounted the customary value assigned to electric over-hand operated machines since coupling and transfer could be adapted more readily to the hand machines.

Tables

In a thoro and painstaking manner Fletcher, Miller, and Rosenhead (51) summarized the mathematical tables published before 1944. Part I of the book consists of an index of tables arranged according to function tabulated. Under each table listed there is noted the number of decimals and figures, the interval and range of the argument, the facilities for interpolation, and the authorship and date. Known corrections, if brief, are then listed, otherwise reference is made to the bibliography of Part II, where sources containing the detailed corrections may be located. Tables which met the authors' unspecified standards of excellence are listed in bold type. Several tables of the normal probability integral, the *t* and the *F* distributions are so listed, but no table of Chi-square appears in bold type. Part II contains a bibliography of some 2000 items, which refer to the tables indexed in Part I, and to books on probability and statistics including applications to education and psychology. Tables developed since 1944 are summarized in *Mathematical Tables and Other Aids to Computation.*

In the literature reviewed there appeared a number of tables of interest to computers in educational research. For interpreting tests of significance several tables may be referred to. The extension of the F distribution table by Merrington and Thompson (103) gives entries to five-decimal places and probability levels extending from 0.005 to 0.50. With reference to the t distribution, Baldwin (8) observed that the use of normal deviates when the degrees of freedom exceeded thirty gave results smaller than the true values. To provide accurate t values she extended the table to 100 degrees of freedom. Thompson and Merrington (130) reported tables for testing the homogeneity of a set of variances which are better approximations than the values based on Bartlett's test. They discussed a common misconception, namely that if the probability of heterogeneity is less than 0.05 or 0.01, the sample variances are treated as tho they were estimates of a common variance. In their judgment this procedure is likely to lead to errors of the second kind in certain instances, but these instances are not specified because that problem has not been investigated mathematically. Pearson and Hartley (111) presented tables for finding the probability that the range of sample A exceeds that of B by a certain ratio, and for finding the limits of the range corresponding to prescribed probability levels. Hartley (65) similarly considered the use of the mean deviation and tabulated its integral. Baker (7) studied the distribution of the ratio of sample range to standard deviation for normal and combinations of normal distributions. Tables were presented for making tests of significance. A simple test of significance based upon signs of differences between pairs of observations was devised by Dixon and Mood (38). Illustrative examples and a table of significance levels were included. This appears to be a useful device for quick appraisals but the efficiency is probably low. Festinger (49) converted scores to rank order and then tested significance between means without reference to frequency distributions. Tables of the 0.05 and 0.01 levels were given. He argued that what the test lost in precision by conversion to rank order was compensated for by the gain in generality since the test could then be used with any distribution. Wilcoxon (141) discussed individual comparisons by ranking methods. Grant (59) considered some of the recent work on probability of "runs" and developed a table and a criterion for testing the significance of responses in learning and problem-solving. Taylor (128) reported tables for determining the significance of skewness and of differences in skewness when expressed in terms of Fisher's g statistics.

Other tables of specialized application are those by Swineford (123, 124), Jurgensen (84), Taylor and Gaylord (129), Lichte (99), Davis (37), Lehmer (95), Croxton and Cowden (35), and Leverett (97).

Carter (25, 26) contrasted the effectiveness of tabular and graphical presentation.

Graphs

Graphical aids noted in the literature reviewed included computing charts or *abacs*, alignment charts or nomographs, slide rules, and other adaptations of graphs to computation. Computing chart, *abac*, construction was described by Peterson and Gulliksen (113). Crow (34) developed a chart of Chi-square and *t* which facilitates interpolation for routine work. Schutzenberger's (117) *abac* of the sample range should enable the computer to apply tests of significance more rapidly but less rigorously than by using the Pearson and Hartley tables (111).

The construction of alignment charts is described by Bond (19), Douglass (39), and Young (143). Hamilton (63) presented a nomograph for the tetrachoric correlation coefficient. Specialized graphical calculation of statistical problems was illustrated by Levi (98), Dufrenoy and Goyan (40), Goyan (58), and Hayes (70).

Some interesting slide rules were developed. Merrill (102) invented a slide-disk calculator for computing root mean squares which bears a striking resemblance to the cylindrical slide rule. The most interesting and potentially useful slide rule for statistics is the film slide rule described by Stibitz (120). Each scale is printed on separate 35 mm. film about 220 feet long. Accuracy is obtained by using the teeth of the sprocket as the unit of measurement rather than the printed scale. The film simply counts the sprocket teeth that pass under a fixed mark, and the scale measures fractional parts of the distances between sprocket teeth. The rule has been made in sizes from three to ten films on each rule with appropriate mechanical connections between sprockets. It has been found to save 80 to 90 percent of the time required for computing over the use of tables and desk calculators.

Callender (24) showed how a simple differential equation could be solved rapidly by using a hatchet planimeter. The ease of constructing such a device may stimulate thinking relative to its application to the integration of empirical curves.

Fiske and Dunlap (50) described a graphical test for significance or differences between frequencies of different samples. Zimmerman (145) reported on apparatus for making orthogonal rotations by projecting coordinates from one plot to another.

Computational Methods and Formulas

Variations of computational procedure involved derivation of new formulas, improvements in matrix calculation and error determination, changes in methods of computing, and the computation of some new statistics.

Guttman (62) described a method for inverting any nonsingular matrix by building the inverse out of inverses of successively larger submatrices. This is a variant of the contribution attributed to Schur. Satterthwaite (116) demonstrated that the solution of a large set of simultaneous equations and the inversion of matrices was complicated by errors due to rounding. If the norm of the matrix was less than 0.35, operations involving the inversion were in a state of error control for Doolittle calculation.

Berry (14) showed that the order in which the elements of the matrix are arranged is important. An arrangement in which the diagonal terms are large and the off-diagonal, especially the post-diagonal terms are small, favors convergence for the iterative method. Bruner (20) came to essentially the same conclusion empirically, and indicated that in the Doolittle solution the check column gave closer agreement if the equations were arranged so that the elements of the principal diagonal increased in going from upper left to lower right. Leavens (94) considered the same problem.

Waugh (138) gave a simple illustration of Hotelling's method of inverting a partitioned matrix by partitioning a square matrix of 2p rows into four square matrices. The inverse was also written as a partitioned matrix. Multiplying the original by its inverse gave four matrix equations which were solved for the four elements. Waugh (137) also presented a formula for computing partial correlation coefficients which is new and should save computational effort. Jenkins (82, 83) considered a systematic arrangement of computation for multiple and partial correlation. Kossack (91) presented a model to be followed in computing many zero-order correlation coefficients from a correlation matrix. Weichelt (140) considered a method of estimating correlation coefficients by expressing r as the ratio between two differences in sums of the dependent variable computed only for extremes of the bivariate distribution. Waugh and Dwyer (139) illustrated compact efficient computation of the inverse of a matrix. Dwyer (43) described a square root or compact method for computing correlation and regression. (By compact he means that the operations are so designed that the machine used carries out many computational steps as a single machine operation.) This is an approximation method and subject to the errors discussed by Satterthwaite (116).

Norton (110) considered calculation of Chi-square for complex contingency tables. He presented a scheme of successive approximations which made the computation systematic. The method provided comprehensive analysis of the contingency table since the interactions as well as the main effect were studied.

Voss (136) described a short-cut for comparing the effectiveness of two methods where a number of experimental conditions were involved. The frequencies of differences between pairs on each condition were tabulated and Chi-square was computed to determine significance of the distribution of differences.

Cowden (32) gave a simple illustration of the application of sequential sampling to an educational problem. In sequential sampling the items are tested one at a time and a decision is made as soon as enough data have been accumulated to justify the decision. One does not know in advance how many items will be needed. The illustration concerned a true-false examination given to decide the student's grade. Good and poor students could be discriminated quickly, so that the illustration was concerned with borderline discriminations. The goal was to reduce the number of questions asked of the student to a minimum and at the same time control the probability of passing a poor student or failing a good one.

By use of "systematic statistics," Mosteller (106) proposed an analysis for large masses of data where the cost of collecting the data was inexpensive compared to the cost of analysis by efficient procedures. Most of the work could be done with a counting sorter. Procedures were given for estimating the mean, standard deviation, correlation coefficient, and the efficiency of each estimate was discussed.

Horton (76) indicated how large sets of random numbers might be obtained thru compound randomization by using a binary rather than a decimal system of numbers. A scheme for reducing symbol bias in shifting back to decimal numbers was discussed. It was proposed that electronic or electrical systems actuated by cosmic rays and the use of tabulating equipment seemed to be feasible for turning out large amounts of random numbers.

Specific computational developments relating to factor analysis and other statistical technics have been discussed in connection with the computing devices rather than the technics. However, the books by Thomson (131) and Thurstone (132) deserve special mention.

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[1] Corrected to January 1, 1949. Report errors immediately to the secretary-treasurer.

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This special number of the REVIEW was planned and prepared by the following committee selected primarily because of the close contact of each of its members with the various phases of research conducted in and for the Armed Forces during the period of the recent conflict generally known as World War II.

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INTRODUCTION

THE PREPARATION of this special number regarding psychological research in or for the Armed Forces was initiated by Alvin C. Eurich, as president of the American Educational Research Association, and the executive committee of the association shortly after the end of World War II. A committee composed of individuals representing several of the various groups of psychologists working on military problems was appointed. The committee agreed that such a review and bibliography could be especially valuable if it were comprehensive and directed attention to the wealth of materials which had not been made generally available and to a large extent probably never would be published in the professional journals. It was also believed that this material could be best reviewed by those who actually participated in the research and were familiar with the essential background and conditions.

Assignments for various chapters and sections were made by the committee and a tentative schedule established. Unfortunately, the pressure of preparing official reports and the extensive personnel shifts during the period immediately after the war necessitated numerous changes both in scheduling and in the responsibilities for reviewing particular materials. In most cases the complete reports were only available in the official files and the committee was therefore dependent on obtaining the cooperation of a small number of individuals who were attempting to carry on the research work initiated during the war. Under these circumstances the assistance of the various collaborators is especially appreciated. The appreciation of the problems and the valuable assistance of the executive committee have been important factors in the completion of this project.

JOHN C. FLANAGAN, *Chairman*

CHAPTER I

General Reports of Research Programs for the Armed Forces

JOHN C. FLANAGAN

During the period of World War II a large amount of research on psychological and educational problems was conducted in and for the various armed services. Because of military security measures and the pressure of current military duties and problems only a small fraction of this research was published in professional journals or otherwise made generally available during the war. The purpose of this review is to bring to the attention of research workers the nature and scope of the research studies conducted so that the experience and findings of the wartime studies may be summarized in a single source.

One of the first groups to become actively engaged in military research in the period preceding the entry of this country into the war was the committee of the National Research Council established at the request of Dean R. Brimhall, Director of Research, Civil Aeronautics Administration. The research in aviation psychology of this group has been reported in a series of Research Reports published by the Civil Aeronautics Administration. The findings of this series of studies have been reviewed by Viteles (5) and are not included in the present survey. This group, of which M. S. Viteles is chairman, is continuing an active program of research. It is now known as the Committee on Aviation Psychology of the National Research Council.

A number of those most active in the early stages of the program discussed in the preceding paragraph entered the Navy after our entry into the war and an Aviation Psychology Branch was established under the direction of the late John G. Jenkins in the Bureau of Medicine and Surgery in the Navy Department in Washington. The reports of this group are reviewed by Ames and Older in Chapter II of this survey. This work is continuing in the same location under the direction of Lieutenant Harry J. Older.

The research program in aviation psychology reviewed by Frederick B. Davis in Chapter III was initiated in the summer of 1941. The research results of this group have been reported in a series of nineteen research volumes under the general title of Army Air Forces Aviation Psychology Program Research Reports (3). The scope of this program has been expanded and it is continuing under the direction of Glen Finch, Acting Research Chief, Division of Human Resources, Office of Research and Development, Headquarters, United States Air Force.

The Adjutant General's Office in the War Department established a Personnel Procedures Section under the technical direction of Walter V. Bingham in the fall of 1940. The numerous research studies carried out by this group have had very little circulation outside of the staff of this group. Therefore the review of these studies by Sisson in Chapter IV should be especially valuable in bringing to the reader's attention work done under the supervision of Marion W. Richardson, Edwin R. Henry, and others who directed this work. This work is continuing under the direction of Donald E. Baier.

The program on personnel research and test development in the Bureau of Naval Personnel did not get started until late in the fall of 1942. The organization was directed by Alvin C. Eurich initially. He was succeeded by Raymond Faulkner. The work is being continued under the direction of Eugene D. Carstater. The work of this group has been reported in a volume (4) edited by Dewey B. Stuit. It was originally planned that this material be reviewed by one of the group who worked in the program. This proved to be impossible. The reviews of the published reports of this group are therefore included in the miscellaneous chapter.

Thruout the war a substantial amount of research on personnel problems was conducted for the Navy by the National Defense Research Committee thru its Applied Psychology Panel. John M. Stalnaker was chairman of the original committee set up to handle this work. He was succeeded by Walter S. Hunter when the panel was formed. This group contracted with various universities and other organizations to carry out specific research and development projects requested by the armed services. The reports of these groups are listed in a bibliography prepared by Bray (1). An official summary report has also been published in two volumes (7). One is on aptitude and classification, the other on training and equipment. Both are edited by Wolfle. Another more popularly written account of the work of these groups has been prepared by Bray (2). Plans for the review of this work by personnel participating in the program could not be carried out and the published reports of this group have also been included in the reviews of the miscellaneous materials.

In addition to the work done under the supervision of the Applied Psychology Panel there was a substantial amount of research done by civilian organizations under other auspices. One of the largest of such programs was the work of the Psycho-Acoustic Laboratory at Harvard University under the direction of S. Smith Stevens. A review of the work of this group is given in Chapter VI.

Another program including a number of psychologists was the service work in assessing candidates for assignments for the Office of Strategic Services. This has been reported in a recently published volume prepared by a group of staff members (6).

One additional set of reports on psychological work done in the services during the war is to be published. This is an account of the work of the Morale Services Division. This work was initiated by Major General Frederic Osborn and was carried out under the immediate supervision of Samuel S. Stouffer and Carl I. Hovland. The four volumes reporting the findings of this group are expected to be available soon.

A number of psychologists rendered valuable services in many other connections during the war. Published reports of many of the studies done under their direction are briefly reviewed in Chapter V. It is believed that a small number of important research studies carried out for the services during World War II have been overlooked. However it is hoped that thru the many reports listed in this review, research workers will be able to benefit from most of the valuable studies carried out during this period.

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CHAPTER II

Aviation Psychology in the United States Navy

VIOLA CAPREZ AMES and HARRY J. OLDER

THE INVESTIGATIONS reported in this chapter have been selected as representative of both the type and the scope of the work developed by the psychologists in the Aviation Psychology Branch, Bureau of Medicine and Surgery, Navy Department, under the direction of Captain John G. Jenkins. Much of the work of the Branch was of an advisory or applied nature which did not lend itself to written reports. Consequently, many aspects of the program are not in written form.*

The development of the naval aviation psychology program up to and following the time of the establishment of the central office in October 1942 may be read in several descriptive summaries (7, 8, 14, 15, 16, 32, 40). Psychologists were originally commissioned to administer, score, and interpret tests for the selection of naval aviation cadets; however, the program soon broadened to include the development of experimental designs for research projects, statistical analyses, methods for selecting flight instructors and aircraft gunners, investigation of attrition, development of training aids, advisory aid to other bureaus, and research on vision and communication.

The principal research groups in the naval aviation program were at Washington, D. C.; Pensacola, Florida; Corpus Christi, Texas; and Jacksonville, Florida. The Washington group was primarily occupied with the administration of the program, the validation of the tests, the development of improved criteria, and consulting services. At Pensacola emphasis was on the investigation of problems of night vision training, disorientation, and intelligibility. Studies on fear and leadership were conducted at Corpus Christi. The Aviation Gunnery Group worked on the development of uniform curriculums for gunnery schools, improved grading systems, and tested special devices (7, 8, 27).

Selection and Classification

About a year and one half before the Pearl Harbor attack, work had begun on the validation of a group of tests for the selection of naval aviators. From the forty different tests investigated, three were selected. Each of these three tests was validated on groups of over 3000 cadets (44).

The three tests originally used were the *Wonderlic Personnel Test (PT)*, the *Mechanical Comprehension Test (MCT)*, and the *Biographical Inventory*. In October 1942 the *Wonderlic Personnel Test* was replaced by the

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* The statements contained herein are the personal interpretations of the writers and are not to be construed as reflecting the views of the Navy Department or the naval service at large.

Aviation Classification Test (ACT). Two forms of this test were developed by the members of the Aviation Psychology Branch in such a manner as to give maximal spread and maximal reliability in the region of the cutting score (31, 23). Both forms had estimated odd-even reliabilities of over .92.

Early investigations indicated the ability of the *Wonderlic Personnel Test* to discriminate between trainees who pass or fail (in aviation training) among low-score groups. However, this was not true for the middle and upper score-range groups. The *Personnel Test* was found to be most valuable for predicting ground-school failures (6). Like the *Personnel Test*, the *Aviation Classification Test* was found to predict academic failures (ground-school training) fairly well, but to be of no value in predicting flight-training failures. Biserial correlations of .29 and .38 are reported for the *Aviation Classification Test* based on all entrants into training versus ground-school training failures.

New forms of the *Mechanical Comprehension Test* were developed by the Psychological Corporation for use in the naval aviation selection program. The estimated odd-even reliability was .80. The test-retest coefficients varied from .84 to .87. That the *Mechanical Comprehension Test* predicted failures for both flight- and academic-training groups is evidenced by the biserial correlations presented by Fiske (6). These range from .14 to .43 for flight training and from .15 to .48 for ground-school training.

The *Biographical Inventory* is a questionnaire with items on biographical information, interests, habits, and attitudes (6, 14, 38, 41). It was originally developed for use in the selection of civilian pilots, but was later adapted to naval aviation selection.

The test-retest reliability was approximately .70 for a group of almost 2000 men. The biserial correlations for the *Biographical Inventory* reported by Fiske (6) range from .15 to .40 for flight-training failures, .06 to .28 for ground-school failures, and .21 to .36 for all failures.

One of the most significant technical advances made in 1942 by the Aviation Psychology Branch was the introduction of a single index to represent various combinations of test scores. This index, called the *Flight Aptitude Rating (FAR)*, combined the grades on the *MCT* and the *BI* (14).

Originally, a table was constructed to show the percent of failures among men obtaining each of the possible combinations of *BI* and *MCT* scores (18). Cells with similar percents were grouped into one of five categories of progressively high failure rates. Later, the scale was divided into nine steps to permit finer discriminations. The biserial correlation between pass-fail groups and the *FAR* was .43. Since this value was exactly the same as the multiple R between pass-fail and the *BI* and *MCT*, it indicated that the *FAR* made the maximum use of differentiations provided by the tests (6).

Early in the program it was found that age correlated with outcome of training. The younger cadets were more likely to graduate than the older ones. It was also evident that extent of previous flight training predicted outcome of training, but not as well as either the *BI* or *MCT*. As for education, cadets with no previous flight training and less than two years of college showed a significantly higher percent of failures than those with no previous training but at least two years of college (6).

Success in the development of technics of selection for naval aviation cadets suggested the feasibility of similar technics for the selection of flight instructors. *Technical Memorandum No. 7* (39) outlined the approach to the project. The steps, in order, were: (a) to identify two groups of flight instructors representing the "tails" of the distribution of instructor ability; (b) to determine specific characteristics which discriminate between these extremes; (c) to develop a scoring key and check its validity. The tests used were: *PT*, *MCT*, *BI*, the *Aviation Preference Check List*, the *Opinions on Flight Instruction Inventory*, and the *Aviation Experience Record*. The last three tests were developed expressly for this study. Data were completed on 905 instructors. Five types of criteria were established. As a result of this study the *Instructor Aptitude Rating Scale* was devised for the selection of instructors.

Trumbull and Vinacke (29) reported an evaluation of the *Diagnostic Scale for Rating Flight Instructors*. The scale was composed of thirty-five items in terms of which a student was asked to assess the merit of his instructor. Thirty-four instructors from two squadrons were used in the trial groups. The results indicated that the five degrees along the scale were far from equal for all questions; several questions were unsatisfactory in terms of consistency of the scale, but the majority of the items were relevant. A revised questionnaire was developed as a result of the study.

An analysis of flight instructor selection technics was reported by Trumbull and Vinacke (28). Well-defined criterion groups of "good" and "poor" instructors were compared. Differences between the groups on components of selection tests were evaluated with the conclusion that the type of material used in these tests was of value in selecting instructors, but a majority of the items did not give the best prediction for the population used in this study.

The Pensacola group worked on questionnaires for selection for advanced training. Many different criteria were used for selection purposes. One of these, low pressure tolerance, was eliminated after completion of Research Project R7-2 on classification tests in low pressure chamber (27).

Training

The aviation psychologists who were attached to the Naval Air Training Commands were engaged in a variety of training projects. Among their contributions were: (a) the development and introduction of improved training records, forms, and procedures; (b) aid in the preparation, evaluation, and revision of syllabi and training manuals for both flight- and ground-school instruction; (c) the improvement of testing methods and grading procedures; (d) statistical analyses of such factors as student flow, causes of attrition, and comparison of records from different training stations (7, 8, 14, 15, 16, 27).

Considerable work was done on the standardization of flight instructor's vocabulary as one of the basic problems of naval aviation training. A technic was developed which permitted sound recordings of all conversations between instructor and student during an instructional flight. The apparatus consisted of a two-way electrical interphone which also served as a modulator for a light-weight high-frequency transmitter. Thru this device it was possible to "listen in" and make recordings on the ground of conversations in the air. These conversations were typed and studied in detail. From the results the "Patter" book for flight instruction was written (19).

At Pensacola various analyses of attrition were made. Among the reports are: "Analysis of Attrition Trends in Aviation Cadets," "Chronological Analysis of Requests To Be Dropped from Training," and "Analysis of Attrition—Primary Land Planes" (27).

A second major function of the Pensacola group was the investigation of visual problems in naval aviation training. Studies of night vision testing instruments, new color testing devices, and night vision training procedures were carried out.

A preliminary report on "Loss of Visual Contrast Discrimination" includes the following statement: "Loss of visual discrimination can be both predicted and measured under conditions of mild anoxia. The particular form of the test (Hecht) is unsatisfactory due to the large proportion of men failing to show the anoxia effect, or failing to comprehend the instructions" (27).

The autokinetic illusion was studied in the laboratory with light stationary, light and/or subject moving, and in night formation flights. Autokinesis is universally experienced by normal persons; the delay in onset with a single light is short. Movement, in one direction, lasts about ten seconds. A single spot is seen to move about half the total fixation time. The illusion is only slightly subject to voluntary control. Increasing the frame of visual reference reduces but does not readily abolish the illusion, and it is reduced by more adequate spatial localization of object, by rapid relative movement of the target, and by shifts in attention. "The Autokinetic Illusion and Its Significance in Night Flying," by Graybiel and Clark (10) reported these findings.

An investigation of the role of vestibular nystagmus in the visual perception of a moving target in the dark by Graybiel, Clark, MacCorquodale, and Hupp (12) is an extension of the above study. Six subjects reported their visual perceptions both during and following rotation while observing a moving target in the dark and in a lighted room. When a subject was accelerated to 15 rpm in the dark, there was a rapid displacement of the target in the opposite direction, altho, at the same time, as a result of nystagmus, the target appeared motionless. Following cessation of rotation to the *right* at 15 rpm the target appeared to move very rapidly to the left. Following cessation of rotation to the *left*, the target appeared to rush rapidly to the right while it was displaced to the right very slowly.

These phenomena, which did not occur in a lighted room, can be considered as a summation of the effects of real motion of the target, vestibular nystagmus, and the subject's sensation of their own motion. These effects have important implications in the explanation of "vertigo" in pilots.

An analysis was also made of the concept of aviator's "vertigo," based upon personal interviews with Naval aviators by Vinacke (48). He concluded that "the term 'vertigo' as used by aviators covers a wide variety of events occurring under many different conditions of flying. The term 'vertigo,' as used by pilots, should be accepted as referring to any sensation, or feeling, which does not accord with observable environmental facts."

The oculogyral and oculogravic illusions were studied in flight using three subjects who observed a fixed luminous target in the dark. Observations were made in the rear cockpit of a standard navy training plane. The subject gave a running account of the apparent motion and displacement of the target while the pilot maneuvered the plane thru different degrees of bank (3).

Studies from the Pensacola laboratory have demonstrated several illusions of movement which may occur in flight. Three of these, the autokinetic illusions, the oculogyral illusion, and the oculogravic illusion were studied extensively.

Vinacke (49) reported a detailed description of the types of illusions reported by a large number of pilots as occurring in aircraft. The illusions described by the aviators were categorized into five general types: visual, nonvisual, conflicting sensory cues, dissociational or recognitional, and general emotional.

The speech intelligibility research program at Pensacola was initiated in 1942. Preliminary research indicated a need for more thoro analyses of the factors contributing to poor intelligibility of voice communications. One study of 200 instructors disclosed that only 14 percent had poor phonation (loudness, pitch, quality), in normal conversation, but 80 percent had poor phonation under simulated flight conditions.

The researches on speech intelligibility covered the message, the talker, the transmission system, and the listener. Early in the program it was noted that certain words have a better acoustic penetration in noise. A study of vocabulary used by gunners in intercommunications procedure revealed that some words had less than 10 percent intelligibility value. Another observation revealed that long words had higher intelligibility value than short words (45).

Speech technics have been developed to improve aerial voice communications. Two types of transmission systems have been studied: (a) the Gosport (acoustical) and (b) the Radio (electrical). Intensive studies of the Gosport speaking type system led to modifications which improved intelligibility of voice transmission. Microphones, earphones, and oxygen masks have been studied, also. The speech laboratory has developed various methods to check listening ability during flight. It found little relationship between audiometric examination results and listening ability in noise (22, 23, 45, 46).

Steer, Lawrence, and others (24) reported an evaluation of the Gosport speaking tube. Flight and laboratory tests were conducted to evaluate the relative advantages of the old and new Gosport. An experimental feedback system which allowed the instructor to hear himself talk to the student was also tested.

The speech intelligibility training program was described in detail by Steer and Hadley (23). They also gave a bibliography of the research projects completed in the laboratory.

Measurement of Proficiency (Criteria)

The Washington group early recognized the lack of systematic treatment of the criterion-to-be-predicted problem. They concerned themselves with efforts to establish methods of collecting and recording criterion data, with the investigations of factors influencing the reliability and validity of the criterion and with the development of technics of analysis. Jenkins (17) in a recent article summarizes the thinking of the group on the more pertinent aspects of the problem.

The principal criterion used for the validation of the various selection devices was outcome-of-training (the award of the "wings" or the dismissal from training). Outcome-of-training was further refined into reason-for-failure, such as ground-training failures, psychologically unsuited, dropped at own request, etc. These criteria naturally, were neither highly reliable nor valid for the prediction of combat pilot success (6, 14, 17).

The first attempt to obtain combat criterion data was made by four naval psychologists who interviewed pilots with combat experience as they returned to the United States. Approaches considered and/or attempted were: (a) to determine what characteristics were important in meeting combat-requirements, (b) to obtain ratings or rankings of all members of an air group, (c) to use decorated versus undecorated pilots, and (d) to use number of planes shot down. It was finally decided to attempt to identify men regarded by fellow pilots as either definitely wanted or definitely not wanted as a member of their combat team.

A member of the Aviation Psychology Branch was sent to the Pacific area to develop basic methods of obtaining combat criterion data. The "high" nominations were sought by asking the respondent to name two men of his acquaintance (living or dead, regardless of rank) on whom he would most like to fly wing in combat. Nominations for the "low" group were obtained by asking him to name two men whom he would not like to have flying wing on him in combat (47).

Further nominations were collected by one psychologist at a west coast port and by four psychologists in the Pacific area. Over 800 respondent pilots with approximately 1600 high and 1600 low nominations were contacted.

The free-response data were later categorized for coding. The original thirty-three unit-categories were reduced to twenty-six. These twenty-six categories when sorted formed five category-clusters (33, 34, 42, 43).

From these categories two checklists were constructed, one for the high or "wanted" pilots and one for the low or "unwanted" pilots. The checklist method yielded 2872 respondents with a total of 4325 nominated pilots. Of these nominees, 2267 were nominated as highs, 1832 were nominated as lows, and 226 pilots were nominated for both high and low by different respondents. The fact that so few pilots received conflicting nominations is taken as evidence of the validity of the nomination technic (35, 36, 37).

In a report of the Combat Criterion Project to date, Carroll (1) reported on the preliminary work, the technic for coding free-response materials into categories, the use of sociometric diagrammatic technics, experimental design, and nature of the population.

An incidental investigation was made of the relationship of frequency of response to importance of response. The results indicated considerably less than a perfect correlation (43). This may have implications for future research.

Trumbull and Vinacke (30), concerned with the problem of a criterion for the validation of flight instructor selection tests, used student evaluations of their flight instructors to establish criterion groups for analysis of selection data. The agreement among six criteria of success was determined, and the 20 percent of instructors rated best and 20 percent rated low were isolated. The six criteria showed agreement. Using a composite of these six, the extremes of flight instructors were defined.

Another approach to the criterion problem was made in the validity study of five targets for testing visual acuity thru the correlation of the test results of each target with the Grow Chart scores. In addition, the test-retest reliabilities of all six tests were studied. Acuity scores, obtained in Snellen equivalents, were translated into log-units to facilitate statistical analysis. Additional systems were assayed for scoring each of the Randolph Field tests (26).

Estimates of the reliability of the Verhoeff test of depth perception were computed in a test-retest study (25). Four scoring methods were studied for their relative reliability and discrimination between levels of depth perception.

Attitudes, Morale, and Leadership

The Corpus Christi group became interested in basic emotional and social problems. One product was a discussion of the psychology of fear with emphasis on how to counteract it. A survey of attitudes and information regarding the war was made. The problem of leadership and organization in patrol plane crews was brought out for examination and treatment (8).

A preliminary questionnaire study was made of the feasibility of using the nominating technic at preflight schools for evaluating leadership and associated qualities of aviation cadets and student aviation pilots. Two questions were asked: "What two men in your present platoon would you select as leaders for the new one?" "What two men in your present platoon would you least desire as leaders of the new platoon?" (31).

Tabulating and Analysis Technics

Much of the work of the naval aviation psychologists consisted of the development of technics of analysis. Unfortunately little of this work has been put into written form.

At Pensacola, Graybiel, Clark, and MacCorquodale (11) reported a method for observing and reporting the effect of angular acceleration and variations in "g" on visual perception during flight. The visual stimulus was a collimated "star" installed in the rear cockpit of a standard navy training plane. All observations were made in complete darkness. Both the pilot's and observer's verbal reports were dictated into an airborne wire recorder which also provided a time limit. These recordings were transcribed in the laboratory, and all analyses made from them. Fiske and Dunlap (9) presented a graphical test for the significance of differences between frequencies from different samples.

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CHAPTER III

Psychological Research in the AAF Aviation Psychology Program

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THE REPORTS of psychological research reviewed in this chapter were written by military and civilian personnel of the Army Air Force Aviation Psychology Program. These reports are all in published form; originally, the reviewer had hoped to include unpublished research reports (of which hundreds are on file), but several considerations made this inadvisable. In the first place, the nineteen *AAF Aviation Psychology Program Research Reports* which were listed by Flanagan (27) include most of the important research findings that were presented in the unpublished documents and that are not subject to restrictions for security purposes. In the second place, the task of reviewing the unpublished materials and assigning credit for the research reported in them proved to be prohibitive.

In addition to the officially approved reports and articles reviewed, this chapter includes a few others that present results of research conducted in the AAF Aviation Psychology Program.

Two articles that were written by personnel of the AAF Aviation Psychology Program about aviation psychology in enemy countries indicated clearly that in this field the air forces of the United States and its allies were far ahead of the German and Japanese air forces. Fitts (22), who served as official representative of the AAF Aviation Psychology Program on a mission to Germany for the purpose of studying the technics and procedures used by German Air Force psychologists during the war, reported that concepts of objectivity, standardization, reliability, and validity were almost completely disregarded by the German psychologists. So far as could be determined, no contributions to technic were made that would be of value to American psychologists. Geldard and Harris (35) visited Japan in November and December of 1945 to assess the work of psychologists in the Japanese Air Forces. They found that both the Japanese Army and Navy Air Forces used batteries of paper-and-pencil tests and psychomotor tests to select men for pilot training. In general, it is interesting to note that, so far as aviation psychology is concerned, Japanese psychologists seemed to be far more advanced than their German counterparts.

It is not generally known how considerable were the contributions of the AAF Aviation Psychology Program to air-crew selection procedures employed by the Royal Air Force, the Royal Canadian Air Force, the Australian Air Force, and the South African Air Force. Special air-crew classification batteries were actually designed for use in the French, Chinese, and Philippine Air Forces. Lyerly (70) has discussed the preparation and use of these batteries in some detail.

Organization and Development of the AAF Aviation Psychology Program

In Report No. 1 of the AAF Aviation Psychology Program Research Reports, Flanagan (25) described the development of the program, its main findings and accomplishments, and their implications for psychology and education. Following a brief introduction (25, Chapter 1), he presented the historical background (25, Chapter 2) essential for an understanding of the program and quoted official directives concerning it (25, Chapter 3). The objectives of the AAF Aviation Psychology Program were stated in 1943 and again in 1945 in articles in the *Psychological Bulletin* (81, 82). The organization and personnel of various research units were also discussed in these articles. Thorndike (101) has summed up the psychological research work in the AAF Aviation Psychology Program under two headings: first, the development and validation of tests for use in selecting and classifying air-crew personnel; and second, the solution of problems required to maximize the combat efficiency of personnel.

Activities of psychologists in the AAF Training Command and some of the results of their work were described in an article prepared by the staff of the Psychological Section, Headquarters, AAF Training Command (89). DuBois (18, Chapter 2) outlined the location and functions of the psychological units in the Training Command and Gilmer and Preston (37, Chapter 8) mentioned some of the administrative problems encountered in their operation. Simon and Berwick (96, Chapter 16) provided information concerning the special services performed during the war by the Statistical Unit of the Psychological Branch in the Headquarters of the Training Command.

In addition to units in the continental United States, several detachments of psychologists were sent overseas for temporary duty. The histories and objectives of these detachments and of other missions undertaken abroad by members of the AAF Aviation Psychology Program were summarized by Lepley (66, Chapters 1, 2). In general, the detachments obtained combat validation data for test scores, made analyses of combat requirements, studied the aptitudes required of lead-crew personnel, and developed proficiency measures for air-crew specialties.

Selection

In the first published account of work in the AAF Aviation Psychology Program, Flanagan (28) reported the initial steps in developing a test for selecting air-crew members in the AAF. This test, first called the *Aviation Cadet Qualifying Examination* and later the *AAF Qualifying Examination*, was further described in subsequent publications (25, Chapter 4; 80), and particularly in a volume edited by Davis (14). The latter traced the development of the *AAF Qualifying Examination* over a period of four years (14, Chapter 1), described the research work underlying its development (14, Chapter 3), and made a general evaluation of its usefulness to the Army Air Forces (14, Chapter 12). The principles employed in constructing this *Qualifying Examination* were set forth in some detail (14, Chapter 2) and should prove of interest to technicians confronted with the problem of assigning individuals to "accepted" or "rejected" groups without regard to individual differences within each group so obtained. The *Qualifying Examination* was constructed to serve a particular purpose, tho it found many uses (14, Chapter 4).

In seven successive chapters of AAF Aviation Psychology Research Report No. 6, Davis (14) reported research on many kinds of test items tried out for use in the *Qualifying Examination*. Of three types of verbal items, reading-comprehension items were most useful for predicting graduation or elimination from pilot training in the AAF (14, Chapter 5). Factorial studies suggested that word knowledge and reasoning in reading are two important skills involved in reading. This result agreed with prewar studies by Davis. Successful efforts to develop tests of factual information that measure interests significantly related to graduation or elimination from pilot training in the AAF were described (14, Chapter 6). The technics employed should prove applicable to the construction of tests for educational and vocational guidance.

Objective test items that measure judgment and reasoning were found by Davis (14, Chapter 7) to be factorially complex. Several reasoning factors were identified, one of which was significantly related to graduation or elimination from pilot training in the AAF. A mental skill believed to be peculiar to what is known as "judgment" was determined and named "evocation," the ability to call relevant information to mind.

The most useful items for predicting performance in pilot training were said by Davis (14, Chapter 8) to be mechanical-comprehension items. An investigation revealed that their variance could be accounted for almost entirely by four independent factors. The design of the factorial study was novel and should be of interest to students of factorial analysis. The usefulness of twenty types of machine-scorable perceptual-test items for predicting graduation or elimination from pilot training in the AAF was discussed by Davis (14, Chapter 9), and methods for ascertaining their efficiency in combination were outlined. Other types of items for which validity data were reported by Davis (14, Chapter 10) included mathematics items, interpretation-of-data items, and printed psychomotor items. The latter were especially recommended for additional research.

The Victory Corps *Aeronautics Aptitude Test* which was widely distributed by the U. S. Office of Education was constructed under Davis's supervision and was described by him (14, Chapter 11). General procedures for devising and refining aptitude-test forms were discussed by Thorndike (101, Chapter 3).

The psychological research on the selection and training of bombardiers in the AAF that was accomplished prior to the establishment of Psychological Research Unit (Bombardier) was summarized by Johnson (55, Chapter 2). Research on the selection of instructors for bombardier schools was reported by Larson (64, Chapter 7), including data that indicated substantial validity for the Instructor-Selection Stanine. Melton presented (73, Chapter 23) information concerning the validation of eight apparatus tests against criteria of performance in bombardier training.

McClelland and Dailey discussed the correlations of twenty-two scores derived from the *Air-Crew Classification Battery* with five criteria of proficiency in flight-engineer training (71, Chapter 5). Intercorrelations of a number of tests constructed especially for selecting flight engineers and tests in the *Air-Crew Classification Battery* were also reported. A complete report on the problem of selecting flight engineers was made in the volume edited by Dailey (13), including a summary of the research up to 1946 and suggestions for future work in the field (13, Chapter 6).

Six phases of the problem of selecting gunners were described by Stolurow and Schrader (98, Chapter 6). Difficulties in obtaining satisfactory criterion variables and practical limitations that prevented the elimination of more than a small proportion of trainees were major handicaps. Schrader, Pascal, and Valentine reported the development of a selection test for gunnery officers, which showed a significant positive correlation with performance in the Combat Gunnery Officers Course (93, Chapter 13). The selection and training of instructors in schools for flexible gunners were discussed by Stolurow, Irion, and Pascal (98, Chapter 12). After consideration of a number of possible criteria, gun-camera scores were chosen for use in experimental studies reported by Melton (73, Chapter 21) on the selection of flexible gunners.

Tests used to select men for navigator training and the research data pertaining to them were described by Carter and Michael (6, Chapter 3). The instruments devised to predict performance as an instructor in navigation schools were considered by Zielonka, Rust, and Rosemark (114), together with data regarding their effectiveness in measuring specified criterion variables.

A series of studies relating to the selection and evaluation of instructors in pilot-training courses in the AAF were reported by Galt and Grier (34, Chapter 14). Work on the prediction of performance in pilot training is reviewed in this chapter in connection with the *Aviation Cadet Qualifying Examination* and the *Air-Crew Classification Battery.*

The history of research work on the selection of radar observers was written by Kunsman (61) and the validation of selection tests for radar-observer training courses was discussed by Kelley (57, Chapter 11). Multiple correlations (subject to shrinkage) of .36 to .50 with criteria consisting of course grades were obtained. Apparatus tests administered at Langley field showed, according to Melton (73, Chapter 22), no significant correlations with any one of four criteria of success in radar training. Intercorrelations of the tests, obtained at Carlsbad Army Air Field, were low.

Mollenkopf and Chaplin reported the design, construction, and use of tests for selecting instructors in the AAF Personnel Distribution Command (77, Chapter 2). Several weighted composite scores (stanines) were derived from these tests. Descriptions of motion-picture tests constructed for aptitude measurement by the Psychological Test Film Unit were presented by Lamkin, Schafer, and Gagne (63, Chapter 5). The tests generally displayed low positive correlations with graduation or elimination from pilot training and contributed so little to the prediction of that criterion that the expense of using them for practical purposes could not be justified.

The most rigorous study of the prediction efficiency of the procedures used in the AAF Aviation Psychology Program for selecting men for pilot training was designed by Flanagan (26). The study was unique and should prove invaluable to students of mental measurement. Thorndike reported the detailed results of the study (100, Chapter 5), which was based on the records of a large sample of applicants for pilot training who were admitted to training regardless of their scores on the *Aviation Cadet Qualifying Examination* and the *Air-Crew Classification Battery*. Case studies were made of sixteen men who obtained low scores on the selection tests and yet succeeded in completing pilot training and on fifteen men who obtained high scores and failed in pilot training. Walton presented two of these case studies as illustrations (105, Appendix C).

Classification

As explained by Flanagan (25, Chapter 4) after initial selection by means of the *Aviation Cadet Qualifying Examination*, men accepted for air-crew training were classified for specialized training as pilots, bombardiers, navigators, gunners, etc. Flanagan outlined the essentials of the classification problem and mentioned the efficiency in the utilization of personnel that can be secured by differential classification. In a volume edited by DuBois (18) the classification program in the AAF was explained in detail. DuBois (18, Chapter 1) recounted the history of and plans for the classification testing of aviation students; in collaboration with Preston, he described the composition of the air-crew classification batteries and certain statistical data derived from their use (18, Chapter 3). Extensive data concerning the validity of stanine scores derived from successive classification batteries were reported by DuBois, Preston, and Peltier (18, Chapter 4). A description of group testing in AAF classification centers and a discussion of the standardization of testing procedures were presented by Gilmer and Preston (37, Chapter 2; 37, Chapter 1). The authors likewise described the personal interviews with aviation students and the criteria used in recommending them for types of air-crew training (37, Chapter 7).

Articles concerning the personnel and organization of Psychological Research Units 1, 2, and 3 appeared in the *Psychological Bulletin* (86, 87, 88). Research activities of the units were also described briefly.

The development of tests for air-crew classification has been summarized in volumes edited by Guilford and Lacey (43) and by Melton (73). Tho these tests were designed for use in the classification battery, the criterion for judging their value was their contribution to the prediction of performance in one or more air-crew specialties, as pointed out by Humphreys (52, Chapter 2) in a discussion of the program of printed-test development. It is reasonable to suppose that quite different judgments of value would have been made had the criterion for judging value been a test's contribution to predicting only that part of an air-crew specialty not present in other specialties for which performance was to be predicted. Yet it is this type of differential prediction that is the crux of the classification problem. In practice, therefore, the *Air-Crew Classification Battery* served as a multiple selection test among men initially selected by means of the *Aviation Cadet Qualifying Examination.*

Following an introduction to tests of intellect and information prepared by Humphreys (52, Chapter 4), Mock described tests of verbal ability (76, Chapter 5), Davis presented data concerning mechanical tests (16, Chapter 13) and mathematics tests (16, Chapter 6), and Fruchter reported the findings regarding a trait called judgment (31, Chapter 8) and the development of information tests (31, Chapter 14). Lacey and Tait reviewed research work on reasoning tests that were not incorporated in the *Air-Crew Classification Battery* (62, Chapter 7) and Zimmerman presented data concerning tests of visualization and offered hypotheses regarding the mental traits measured by these tests (115, Chapter 12). The construction of measures of foresight and planning, and data pertaining to their factorial composition, were discussed by Guilford and Mock (43, Chapter 9). These authors also reported the development of tests of integration, the latter being defined as the ability to pay attention to several variables simultaneously and to respond to a combination of them (43, Chapter 10). Research on memory tests was reviewed by Lipman, Patterson, and Shirley (67, Chapter 11). Evidence of the existence of three independent factors thought to represent aspects of memory ability was adduced.

The outline of plans for constructing perceptual tests was provided by Lacey (62, Chapter 15). Zimmerman discussed the development and factorial composition of perceptual speed tests (115, Chapter 16) while Lacey described the printed tests of form perception developed for possible use in the *Air-Crew Classification Battery* (62, Chapter 17). The nature of eleven tests of size and distance was considered by Lacey and Shirley (62, Chapter 18) and their value as tests of pilot aptitude was mentioned. Lacey and Niehaus (62, Chapter 20) reported efforts to measure the ability to determine one's location relative to landmarks, while tests designed to measure other spatial abilities were discussed and their factorial content hypothesized by Howe and Zimmerman (51). Fruchter (31, Chapter 21) described experimentally developed measures of set and attention.

The general approach to the problem of organizing and presenting material for testing emotion, temperament, and personality was outlined by Guilford (43, Chapter 22). According to Cerf (8, Chapter 23), personality inventories and questionnaires that were commercially available in 1942-1945 failed to yield scores significantly related to performance in pilot training in the AAF. Furthermore, Cerf concluded (8, Chapter 24) that predictions of such performance made by clinicians on the basis of sets of test scores and subjective judgment were of little or no value. A description of the biographical data blank adapted by the AAF from the form used by the Civil Aeronautics Administration and the Navy Bureau of Medicine and Surgery was provided by Mock (76, Chapter 27), who presented evidence of its value. Measures of specific traits of temperament that were developed or tried out in the AAF Aviation Psychology Program were discussed by Davis (16, Chapter 25). Grossman presented data (41, Chapter 26) concerning tests of motivation.

One of the most interesting fields of investigation of the AAF Aviation Psychology Program was that of mass testing with apparatus tests. The history of the development of these tests was recounted by Melton (73, Chapter 1), who has discussed the problems arising in the course of the unprecedented use of apparatus tests and the technics devised to cope with these problems (73, Chapter 2). Melton has summarized (73, Chapter 25) the conclusions reached on the basis of over four years of intensive research. He has also discussed technical considerations, such as methods of determining reliability coefficients for apparatus tests and of obtaining suitable criteria for validating them (73, Chapter 3). The mechanics of testing large numbers of aviation students with psychomotor apparatus were explained by Gilmer and Preston (37, Chapter 3).

Among the standard classification-battery tests for which Melton has provided detailed specifications and elaborate data concerning their reliability and validity were the *SAM Complex Coordination Test* (73, Chapter 4), the *SAM Two-Hand Coordination Test* and the *SAM Two-Hand Pursuit Test* (73, Chapter 5), the *SAM Discrimination Reaction Time Test* (73, Chapter 6), the *SAM Rotary Pursuit Test* and the *SAM Rotary Pursuit Test With Divided Attention* (73, Chapter 7), the *Rudder Control Test* (73, Chapter 8), the *Santa Ana Finger Dexterity Test* (73, Chapter 9), six tests of steadiness designed to measure the effect of emotional stress (73, Chapter 10), and two Pedestal Sight Manipulation tests intended to select men for training as B-29 gunners (73, Chapter 11). It was found experimentally that the psychomotor tests in combination made a significant contribution to the prediction of such criteria as performance in pilot training obtained from the use of paper-and-pencil tests alone. One of the questions left unanswered by research completed during the war was whether paper-and-pencil tests could be developed to the point where the unique contribution of apparatus tests would be too small to warrant the expense of developing and administering them.

In addition to the apparatus tests actually employed in the *Air-Crew*

Classification Battery, Melton has listed many others that were still in the experimental stage at the end of the war. He has presented as much data about these as can be released under security restrictions. The tests included six designed to measure compensatory visual-motor reactions (73, Chapter 12), six that measure visual-motor pursuit skills (73, Chapter 13), four path-tracing tests together with variations of three of these (73, Chapter 14), several coordination tests (73, Chapter 15), and nine visual discrimination-reaction tests (73, Chapter 16). Others were seven timing-reaction tests (73, Chapter 17), twelve manipulation and motility tests designed to aid in the selection of bombardiers and radar operators (73, Chapter 18), eight stress tests, one of which (the Falling Hammer) was validated against combat criteria by a detachment in England under the leadership of Lieutenant Colonel Paul Horst (73, Chapter 19), a large number of psychophysiological measures developed and studied extensively by M. A. Wenger (73, Chapter 19), and eight miscellaneous tests including measures of kinesthetic discrimination, foresight and planning, muscular coordination, sway compensation, and stability of orientation, as well as the *AAF Physical Fitness Test*, the *SAM Control Sequence Memory Test*, and the *Minnesota Assembly Test* (73, Chapter 20).

Because of the need for placing air crews of the highest quality in lead planes, considerable research was undertaken to measure the abilities required of men in lead planes. This was summarized by Lepley (66, Chapter 9).

Training

Research on various aspects of training in the AAF was presented by Flanagan (25, Chapter 6). He discussed the content of training courses, the amount and rate of learning that took place, and the evaluation of training devices. The selection of instructors was also considered. Thorndike mentioned some of the problems of training experiments (101, Chapter 10).

Most of the research work on training problems was undertaken by the AAF Aviation Psychological Research Projects at Training Command installations. An account of the history, organization, and research activities of the Psychological Research Project (Bombardier) was presented briefly in the *Psychological Bulletin* (83) and in considerable detail in the volume edited by Kemp and Johnson (58). The latter wrote a brief background history of the training of student bombardiers and of instructors for bombardier training schools (55, Chapter 1), calling attention to the fact that over 47,000 bombardiers were trained in the AAF between the attack on Pearl Harbor in 1941 and the surrender of Japan in 1945. He also outlined the organization and mission of Psychological Research Project (Bombardier) of which he was Assistant Director (55, Chapter 3). Kemp and Helmick reported an experimental study designed to show the improvement in circular error resulting from increasing the number of bombs dropped during the bombardier training course (58, Chapter 8). Johnson (55, Chapter 10) summarized the work of the Psychological Research Project (Bombardier) and together with Kemp offered suggestions for future research in aviation psychology (58, Chapter 11).

Psychological research concerning the selection and training of flight engineers began at Psychological Research Unit No. 2; later it was centered in the Psychological Research Project (Flight Engineer) at Hondo, Texas. The research projects undertaken and the trends that influenced their choice were outlined by French, McClelland, and Dailey (29). According to McClelland, Canfield, and Dailey, flight-engineer training was begun in April 1943 when excessive losses of bombardment aircraft on long over-water flights demonstrated the need for an air-crew member trained to operate engines at optimal power settings (71, Chapter 5).

The psychological research carried out on flexible-gunnery training was reported in AAF Aviation Psychology Program Research Report No. 11, edited by Hobbs (50). He has written a brief history of the training of flexible gunners (50, Chapter 1), has pointed out the role of psychologists in the training program (50, Chapter 4), and has made a critical evaluation of the contributions of psychological research to gunnery training (50, Chapter 15). With Schrader (50, Chapter 11), he explained how psychologists prepared curriculums, lesson plans, manuals, etc., for the training courses, formulated principles of program planning, and systematically evaluated the training programs. A description of the typical gunner in the AAF was written by Pascal (79, Chapter 3); the gunner was said to be about twenty-three years of age, a high-school graduate, and about half a standard deviation above average in mental ability. His motivation during training was not good. A description of several training devices used in flexible-gunnery training was given by Vallance and Schrader together with evaluative information pertaining to them (103, Chapter 9).

The establishment of the Psychological Research Project (Navigator) in the AAF Training Command was described by Carter (6, Chapter 4) and a list of the personnel attached to it was presented (84). A complete account of the work of the project was made available in the research report edited by Carter (6), who also prepared a summary of psychological research in navigator training with suggestions for future planning and research (6, Chapter 13). Michael outlined the role of the navigator in the AAF, the selection of men for navigator training, and research in the problems of navigator training (74, Chapter 1). Suggestions regarding the length and arrangement of the content of the course in navigation resulted from a study of dead-reckoning navigation that was made by Dudek (19, Chapter 8). With Glaser, Dudek also reported the nature and results of a rigorous evaluation of a special training aid used in navigation training in the AAF-trainer, the so-called G-trainer. Important methodological implications may be derived from this study.

In AAF Aviation Psychology Program Research Report No. 8, edited by Miller (75), psychological research was reported on objective measures of flying skill, printed tests of flying information, subjective measures of flying proficiency, job analysis, and instructor selection and evaluation (75, Chapter 1). Prior to this, the functions, history, and personnel of the Psychological Research Project (Pilot) had been listed briefly and its research activities discussed at some length (85). Ericksen outlined the organization of the AAF Training Command and briefly described its functions (20, Chapter 2). Two controlled experiments in the training of pilots were summarized by Galt (34, Chapter 13). The results indicated that the use of twin-engine airplanes in basic pilot training improves performance on twin-engine airplanes in advanced training and that the use of optical sights on shotguns used for skeet training is desirable. The effect of adding five weeks of training to the normal courses in pilot training in the AAF was studied and the procedures and results were reported by Miller, Galt, and Gershenson (75, Chapter 10). A summary of the work of Psychological Research Project (Pilot) and recommendations for further work in the field were provided by Miller (75, Chapter 15).

Psychological research on radar-observer training in the AAF was presented in a volume edited by Cook (10). The problems encountered in selecting and training radar observers were mentioned and the procedures employed to solve them were discussed. Cook compared the use of batteries of tests of relatively uncorrelated mental traits with the use of batteries of work-sample tests (10, Chapter 12). As would be expected when two batteries of tests measured essentially the same mental skills in two different combinations, both batteries turned out to provide approximately equal accuracy of prediction; in such a situation, the differences in intercorrelations of the parts of the two batteries could have no appreciable effect on their accuracy of prediction of a single criterion. Hastorf (48, Chapter 1) defined the scope of AAF Aviation Psychology Program Research Report No. 12 and outlined the essential principles of radar, its adaptation to airborne use in combat operations, and the training program for radar observers in the AAF (48, Chapter 2). He also wrote (48, Chapter 3) a brief summary of research on the selection and training of radar observers accomplished under the auspices of the National Defense Research Committee and by Psychological Research Project (Radar).

Studies of the acquisition and retention of air-crew skills were reviewed and some data pertaining to the retention of these skills during periods of inactivity were presented by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 12). The instructional technics peculiar to the use of motion pictures, together with data regarding their effectiveness as teaching devices, were discussed by Gibson, Borin, Orvis, and Gagne (36, Chapter 10).

Measurement of Proficiency and Criterion Studies

Studies of the proficiency of bombardiers, flight engineers, flexible gunners, navigators, pilots, and radar observers were summarized by Flanagan (25, Chapter 5). Crawford, Sollenberger, Ward, Brown, and

Ghiselli edited Report No. 16 in the series of AAF Aviation Psychology Program Research Reports, which included data regarding the analysis of duties, the criteria of proficiency used for validation purposes, and the validity data for a number of air-crew positions (12). Their introduction to the report (12, Chapter 1) indicated its scope and purpose. That the most fundamental and, in many respects, the most difficult problem faced in the AAF Aviation Psychology Program was the definition and measurement of satisfactory criterion variables was pointed out by Thorndike (101, Chapter 4). Ultimate criteria were formulated but were rarely measureable. Intermediate or even immediate criteria were therefore used and supplemented with professional judgment. This is an excellent discussion of an important methodological issue. Efforts were made to maximize the relevance of available criteria and to minimize bias in them; of secondary consequence were efforts to maximize the reliability of criterion variables.

Kemp discussed the development of phase checks to serve as criteria for validating tests used in the selection of bombardiers (58, Chapter 4). Proficiency tests were constructed to provide measures of the practical knowledge about bombing and navigation required of bombardier students. These tests were described by Johnson (55, Chapter 5) and sample items were presented. An evaluation of various measures of proficiency for use in bombardier training was reported by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 7). Johnson described (55, Chapter 6) surveys of the level of proficiency of aerial instructors and supervisory personnel at cadet bombardier schools and in the AAF Central Instructors School (Bombardier). Johnson (55, Chapter 9) also reported research on the development of a motion-picture test for target and check-point identification, a study of the reliability of the circular error and of the percent of hits for C-1 autopilot bombing, and the results of several minor studies.

Research work, designed to improve existing criteria for judging the performance of flight engineers and directed at the development of new criteria was described by Seaman, Unger, Dailey, and McClelland (94). The fact that Navigator Stanine scores have some promise for predicting performance in ground-school courses in operational training was indicated by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 8) in studies of criteria for judging the proficiency of flight engineers.

Stolurow stated that the measurement of proficiency among students at gunnery schools was at first ineffective (98, Chapter 7). Gradually, the situation was improved as well-constructed examinations became available and were uniformly administered and interpreted. Data concerning four forms of the *Final Comprehensive Examination* were presented. To meet the need for practical tests of proficiency in operating, caring for, and checking equipment, phase checks were developed, as described by Valentine (102, Chapter 8). A study made by Johnson and Milton (56, Chapter 18) showed that a marked increase in accuracy of aiming a B-29 Pedestal Sight could be secured by redesigning the controls in the light of human capabilities and limitations.

As part of the task of establishing procedures for selecting lead crews, research reported by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 10) was undertaken to provide analyses of proficiency measures and synthetic-trainer scores for flexible gunners in operational training. These editors also reported research on evaluating the proficiency of air-crew members to provide criteria for selecting lead crews (12, Chapter 11).

Research related to the development of aerial measures of navigation skill (97, Chapter 6) and objective ground measures of navigation skill (97, Chapter 5) was described by Smith. Data resulting from studies of the graduation-elimination criterion and of the grades given in navigation schools were reported by Michael and Rosemark (74, Chapter 7). Analysis by Dudek, Peltier, Smith, Lyon, and King of the procedures used to determine position by means of dead-reckoning navigation indicated the relative importance of each of these procedures and provided leads for improving the teaching of dead-reckoning navigation and for decreasing "distance-off" (19, Chapter 9). The duties of the navigator in operational training and criteria for judging his proficiency were presented by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 6).

Problems involved in measuring pilot proficiency were discussed by Miller (75, Chapter 4) while Ben-Avi described the grades assigned to students during their flying training together with analyses and evaluations of them (2). Objective measures of flying skill that were developed for use in primary pilot training were presented by Youtz (113, Chapter 6); objective measures of single-engine instrument-flying skill were discussed and evaluated by Hagin (47, Chapter 9) while Ericksen described the nature and use of objective measures of multi-engine instrument-flying skill (20, Chapter 8). Four studies concerning the measurement of pilot skill in flying two-engine airplanes were also reported by Ericksen (20, Chapter 7). Fixed-gunnery scores as objective measures of flying skill were evaluated in research studies summarized by Gleason (38, Chapter 11). The development and the use of printed tests of flying information were considered by Robbins and Levine (91). A series of studies on proficiency measures and their validation were reported by Crawford, Sollenberger, Ward, Brown, and Ghiselli concerning the fighter pilot (12, Chapter 2), the photo-reconnaissance pilot (12, Chapter 3), the co-pilot (12, Chapter 5), and the airplane commander (12, Chapter 4). Investigations of fighter-pilot proficiency, the prediction of fighter-pilot combat proficiency, and fatigue factors in long-range fighter missions were summarized by Lepley (66, Chapter 10) from reports written by the investigator, Lieutenant Wilse B. Webb, an aviation psychologist attached to the 413th Fighter Group. Fitts reported the accuracy with which AAF pilots can reach objects placed around them when they are unable to see either the objects or their own bodies (23, Chapter 15). Accuracy is greatest reaching forward and below shoulder level.

Graff, Kelley, and Hastorf discussed the development and content of five printed tests for measuring the proficiency of students in radar training (39). The intercorrelations of several of these proficiency tests were presented by Kriedt, Johnston, and Kunsman (60), who pointed out the considerable amount of overlap indicated by the data. Six standardized performance tests, developed to supplement the measurement of radar-observer proficiency by means of paper-and-pencil tests were described by Bray (4, Chapter 6). Sources of unreliability in the performance-test scores were discussed (4, Chapter 7) and two concepts of validity were mentioned. The use, reliability, and relationships of the circular error in radar bombing with other measures of proficiency were reported by Klein (59, Chapter 9). It was concluded that thirty to thirty-five hours of training are insufficient to develop a high degree of skill in radar bombing. No satisfactory criteria for validating measures of proficiency for radar observers in operational training were found, according to Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 9).

Gibson reported the construction and use of motion-picture tests for measuring proficiency in aircraft recognition and target identification (36, Chapter 6). In collaboration with Gagne, he presented experimental data on several aspects of aircraft recognition (33). Evaluations of the Renshaw system and of some alternative training procedures were made. Davis described the construction of several specialized examinations used by the AAF, including the *Aviation Cadet Educational Examination,* the *Flight-Officer Examination,* the *AAF English Expression Test,* and the *Victory Corps Aeronautics Aptitude Test* (14, Chapter 11). Experiments reported by Melton (73, Chapter 24) revealed significant impairment of proficiency on both paper-and-pencil and apparatus tests at 15,000 to 18,000 feet without oxygen and at 45,000 feet with oxygen. Performance on an addition test was found especially sensitive to changes in altitude.

In spite of innumerable difficulties, more than 1872 different indexes of the combat validity of the selection and classification tests used in the AAF were obtained. In a research report edited by Lepley (66), these data were reported and discussed. Two faults of criterion data were said by Lepley (66, Chapter 3) to be low reliability and bias. The criteria used included objective measures, administrative actions, direct and systematic observations, and ratings based on general impressions. Lepley described the use of proficiency tests for assembling lead crews and for detecting the need for precombat or refresher training (66, Chapter 8). The tests found to be most predictive for bombardier criteria of combat effectiveness were Spatial Orientation I and II, Mathematics A and B, Mechanical Principles, Discrimination Reaction Time, and the Pilot Stanine (66, Chapter 4). Of thirty-seven variables correlated with several measures of navigator effectiveness in combat, Lepley reported (66, Chapter 5) that sixteen had predominantly positive correlations. The four best predictors were Technical Vocabulary (Navigator), Technical Vocabulary (Pilot), Arithmetic Reasoning, and Mathematics B. The absolute magnitudes of the validity coefficients were not especially meaningful because of marked attenuation resulting from the rigorous selection of navigators at classification centers on the basis of the Navigator Stanine. A total of 889 validation statistics, using the combat effectiveness of pilots as the criterion, were presented by Lepley (66, Chapter 6). Greatest effectiveness was found for predicting fighter-pilot performance. The most useful classification tests were *Mechanical Principles, SAM Two-Hand Coordination, SAM Rotary Pursuit, Spatial Orientation I and II, Aiming Stress* (portrayed on the stage in *Winged Victory*), and *Table Reading*. Criteria of success in combat different from those employed in the studies summarized by Lepley were utilized by Mollenkopf. He found no evidence of significant relationships between the criteria he used and various selection tests (77, Chapter 4). Lepley summarized the psychological research work done in various combat areas by sixteen officers and three enlisted men on temporary duty (66, Chapter 11).

Studies of Requirements

Studies of the requirements of air-crew positions were made at various times in the AAF Aviation Psychology Program and for many different purposes. Job requirements for the bombardier, navigator, and pilot were reported by Walton (106). Thorndike summarized (101, Chapter 2) the job-analysis procedures employed as a basis for test construction: (a) review of existing literature, (b) analysis of records of performance, (c) interviews with air-crew personnel, (d) direct experience on the part of psychologists, and (e) correlation of tests and criteria.

A description of tasks performed by students in flight-engineer training schools was presented by Schmonsees, Unger, Riecken, and McClelland (92), who also made a job analysis in terms of psychological traits. According to Valentine (102, Chapter 2), the task of the flexible gunner was ordinarily that of firing at a target (an attacking fighter plane) from a platform (a bomber) also moving in three dimensions. A discussion of the skills and abilities involved in gunnery was prepared by Irion (53, Chapter 5), who also considered the use of synthetic trainers as criterion measures.

A job analysis of the navigator's task and the attributes of a successful navigator were presented by Whiteside and Glaser (109). Youtz has provided a convenient summary of the skills and abilities required of a pilot (113, Chapter 3, Part I) and Ericksen made an analysis of the pilot's task in specialized types of activities, such as instrument flying, night flying, navigation, and formation flying (20, Chapter 3, Section II).

Kelley reported a job analysis for radar observers (57, Chapter 4) made largely in terms of mental abilities defined by centroid factors to which names were ascribed on the basis of subjective judgment. Investigations of the combat requirements for air-crew personnel were summarized by Lepley (66, Chapter 7), and Flanagan discussed research on mission failures and on errors of personnel during operations in combat (25, Chapter 7).

Attitudes, Morale, and Leadership

Research on attitudes, morale, and leadership was conducted by the AAF Aviation Psychology Program largely in the AAF Personnel Distribution Command in redistribution stations or convalescent hospitals. Many of the studies made in these installations were summarized by Flanagan (25, Chapter 8), among them investigations of fear and courage in aerial combat, anxiety reactions, counseling and therapy, and attitudes and preferences of combat returnees.

Psychological research on problems of redistribution was summarized in a report edited by Wickert (110). In this report, Wickert recounted the history of psychological research in AAF redistribution stations and listed the personnel engaged in it (110, Chapter 1); he also made an over-all evaluation of the work and mentioned the potential value of data that were gathered but not fully analyzed during the war (110, Chapter 8). Crannell and Mollenkopf outlined the extensive research conducted to determine the essentials of combat leadership (11). Methodological problems of research in leadership were stressed and the instruments used were described. Studies conducted to ascertain the nature of anxiety reactions in combat were reported by Shaffer (95, Chapter 5). The tests used to select air-crew personnel were found to be unrelated to the presence or absence of anxiety reaction as determined by psychiatric examination. A Personality Inventory was developed, however, which consistently showed biserial correlations of the order of .50 with the criterion. With Kamman, Lecznar, Pearson, and Williams, Shaffer discussed surveys of fear and courage in aerial combat, of the psychological causes of mission failures, and of disorientation in instrument flying (95, Chapter 6). The attitudes and preferences of AAF air-crew personnel returned to the continental United States from combat zones were described by Shaffer and Pearson (95, Chapter 7). Differences among fighter pilots, bomber pilots, bombardiers, and navigators were pointed out.

The attitudes and opinions of flexible gunners who had recently returned from combat, had graduated from a training school, or had not entered into combat were reported by Irion (53, Chapter 10). Some of the problems encountered in training navigators who had been returned from combat and assigned to the AAF Instructors School for Navigators were outlined by Friedman, Rosemark, Heathers, Grigg, and Zielonka (30). A study of the attitudes of air-crew personnel (both officer and enlisted) returned from combat toward further duty assignments of various types was described by Crawford, Sollenberger, Ward, Brown, and Ghiselli (12, Chapter 13).

Bijou (3) edited a volume of the AAF Aviation Psychology Program Research Reports concerning research in AAF convalescent hospitals. The need for and development of the psychological services and research work in these hospitals was stated by Bijou and Gillman (3, Chapter 1). The psychological services were described in detail by McNeill, Heathers, Rotter, Willerman, and Lawrence (72), including evaluation procedures and individual and group counseling technics. Research activities were outlined by Bijou and Heathers (3). The tests and inventories that were used were mentioned and the criteria used to validate them were listed. These same authors also prepared a summary and evaluation of all the service activities and research work of psychologists in the AAF convalescent hospitals (3, Chapter 11).

Data derived from the administration of five personality inventories were summarized by Heathers (49), who concluded that all five of them possessed substantial utility. Lawrence and Levine investigated attitudes of patients in AAF convalescent hospitals (65, Chapter 5) and Lawrence reported data suggesting that biographical information may be useful in making prognoses for convalescent patients (65, Chapter 6). Descriptions of a number of interest questionnaires used in AAF convalescent hospitals and results obtained from their use were presented by Lucio and McReynolds (69).

In an effort to measure the impairment of mental efficiency associated with psychiatric disorders, the *Shipley-Hartford Retreat Scale* for measuring mental impairment and a new *Efficiency of Mental Application Test* were tried out in the convalescent hospitals. Bijou and Lucio discussed the findings, noting that both tests showed promise, particularly the test assembled especially for use in the AAF (3, Chapter 8). Three projective tests were used in the convalescent hospitals by psychologists in the AAF Aviation Psychology Program: the *Rorschach Test*, the *Bender Visual-Motor Gestalt Test*, and the *Incomplete Sentences Test*. Of the three, the last seemed to differentiate best between normal and maladjusted patients. These data were reported by Wischner, Rotter, and Gillman (112). An ingenious method of quantifying interpersonal behavior in group counseling was described by Willerman and Pascal (111) and an illustration of its use was given.

In an article published in the *Psychological Bulletin* (79), Super discussed case studies and clinical evaluations of aviation cadets together with the projective technics employed. Tho most of the work of the AAF Aviation Psychology Program was concerned with mass testing by means of objective measures, elaborate studies of clinical procedures were made on samples of aviation students in order to assess their efficacy. In general, the data showed that clinical evaluations did not add anything to predictions of performance made solely on the basis of machine-scorable objective tests.

Tabulating and Analysis Technics

Elaborate safeguards were employed in test-scoring operations of the AAF Aviation Psychology Program to prevent and catch errors. The procedures used in scoring classification tests were described by Gilmer and Preston (37, Chapter 4). These authors likewise discussed the routine checks and statistical technics employed to insure comparability in the classification-test scores derived from apparatus tests (37, Chapter 5).

Because validation of test scores obtained at classification centers and psychological examining units against performance in training courses and in certain air-crew duties was the foundation stone of research carried on in the AAF Aviation Psychology Program, it was essential to have an accurate, complete, and convenient records system. Gilmer and Preston described the routine of handling records in psychological examining units (37, Chapter 6) while Simon and Berwick described the records system at the Headquarters of the AAF Training Command (96, Chapter 10), where test scores from many examining units were filed together. The basic records files (96, Chapter 11) and the training-data files (96, Chapter 12) maintained in the Psychological Section at Headquarters, AAF Training Command were also discussed by Simon and Berwick (96, Chapter 13). These authors mentioned everyday problems encountered in the collection and maintenance of machine records and made suggestions for avoiding them (96, Chapter 17). They discussed the types of errors common in machine-records operations and methods used to control them (96, Chapter 18). General considerations in the establishment and use of machine-records systems, with illustrations from their experience in the AAF Aviation Psychology Program, were presented by Simon and Berwick (96, Chapter 9). They also discussed the dissemination of data by means of roster, punched cards, and microfilms (96, Chapter 14).

In AAF Aviation Psychology Program Research Report No. 3 edited by Thorndike (101), some of the technical problems encountered in psychological research work during the war were considered and the procedures developed to meet them were summarized. Special attention was given to problems associated with the selection and classification of personnel. To express validity coefficients, the product-movement r was used whenever possible. With dichotomized criteria, biserial rather than point-biserial r's were computed in order to minimize the effect of variation in the position of the dichotomic line on validity coefficients obtained in different samples. Thorndike discussed these and other correlation statistics used in determining the validity of single tests (101, Chapter 5) and presented the formulas used to correct for restriction of range due to prior selection. Procedures for obtaining composite aptitude scores were outlined by Thorndike (101, Chapter 6). The multiple-regression and multiple-cutoff methods were contrasted and the reasons for choosing the former for use in the AAF Aviation Psychology Program were mentioned. A formulation of the problem of a unique classification system was presented. Emphasis was given (101, Chapter 8) to the significance of the intercorrelations of a set of variables proposed for use for selection purposes. Three types of prediction problems were identified: selection, multiple selection, and classification. The importance of test reliability as an aid to interpreting test-validity data was stressed by Thorndike (101, Chapter 7) and various ways of computing reliability coefficients were mentioned. An analysis of the sources of variance in test scores was especially noteworthy (p. 102-103). Several formulas developed by A. P. Horst to determine the loss of test validity ascribable to extraneous variance in test scores were presented by Thorndike (101, Chapter 9). Methods used to minimize extraneous variance in test scores obtained in the AAF Aviation Psychology Program, especially in apparatus-test scores, were found to be highly effective.

Most research workers will want to become familiar with parts of AAF Aviation Psychology Program Research Report No. 18, edited by Deemer (17). In this report Alchian has written four chapters on the methods of statistical analysis employed in the AAF Aviation Psychology Program that are notable for their presentation of up-to-date concepts in surprisingly compact and straightforward fashion. The basic principles of modern statistical analysis and inference were stated succinctly (1, Chapter 20) and were followed by detailed descriptions of the procedures used to estimate the parameters of univariate distributions (1, Chapter 21). The statistics employed in bivariate analyses were set forth with the tests of significance appropriate for use with them (1, Chapter 22) and technics of multivariate analysis were described with special reference to regression statistics (1, Chapter 23).

This research report (No. 18) also includes two interesting chapters written by Simon and Berwick on machine technics. In one of these, detailed procedures for obtaining biserial correlation coefficients and intercorrelations were presented (96, Chapter 15), and in the other a method for obtaining the sums of squares and of products with the IBM alphabetical accounting machine was described (94).

Statistical procedures commonly used in one or two psychological research units for computing reliability coefficients, item-analysis data, validity data, and factorial data regarding items and tests were outlined by Humphreys (52, Chapter 3). The type of internal-consistency and external-criterion item-analysis data used in the development of the *Aviation Cadet Qualifying Examination* and many other examinations was explained by Davis (14, Appendix A). Detailed instructions for computing the data as well as evidence of its reliability were provided. Item difficulty indexes were found to be more reliably determined than item-test correlation coefficients. Guilford discussed the factorial composition of a large number of the tests developed for use in classifying aviation students and related these data to the criteria that were to be predicted (43, Chapter 28).

Design of Equipment

The establishment of a Psychology Branch in the Aeromedical Laboratory at Wright Field, as reported by Fitts (24), provided a central point for psychological research on the design of equipment. Previously, considerable work in this area had been accomplished in the AAF Aviation Psychology Program, but no organization had been specifically charged with the responsibility. A report edited by Fitts (23) presented the research data accumulated on the design of equipment with regard to human capabilities and limitations. The nature of engineering psychology and its applications, methods, and technics were discussed by Fitts (23, Chapter 1). Problems associated with the means of presenting information obtained in the form of instrument readings were described by Grether (40, Chapter 2). Brown and Jenkins prepared an outline of research related to the design of equipment, which was based on an analysis of human motor abilities (5). A bibliography was appended.

A number of studies have been made to determine how aircraft instruments and accessory materials should be designed to minimize errors in using them. Comparing the relative ease and accuracy with which tables and graphs were read, Carter concluded that tables are preferable as a means of presenting data if interpolation is not required. If it is, graphs are to be preferred (7, Chapter 4). The sources of error in reading air navigation plotters were identified and, according to Christensen (9), a new plotter has been designed that should prove considerably easier to use. Grether has shown that a twenty-four-hour dial face on a clock is easier to read than a twelve-hour dial face provided that time is to be read according to the twenty-four-hour system (40, Chapter 6). Optimum characteristics of a twenty-four-hour clock face were determined. Some findings with respect to dial faces are interesting; Grether and Williams discovered (40, Chapter 7) that the accuracy with which dials were read increased as their diameters were increased up to two inches. It also increased as gradations were increased to seven-tenths of an inch. On the other hand, speed of dial reading did not appear to be related to size of dial diameter or scale interval. A study of the interpretability of various types of aircraft attitude indicators, made by Loucks (68), showed that for blind flying the horizon should remain fixed and a three-dimensional miniature aircraft should constitute the moving element and should move in the direction in which the plane rolls.

Another group of related studies pertained to airplane control knobs and their uses. Weitz (108) concluded that coding control knobs by color and shape helped reduce the difficulty normally experienced when a pilot shifts to an unfamiliar airplane in which the controls are placed differently. Experimentation with control knobs of various shapes has indicated, according to Jenkins (54, Chapter 14), that knobs of certain shapes are less frequently confused than others and should be standardized for use in aircraft cockpits. Data obtained by Grether (40, Chapter 17) showed that airplane controls can be handled more efficiently with the arms and hands than with the legs and feet. Fore-and-aft movements were found more efficient than lateral movements. If a group of controls must be adjusted rapidly in a certain sequence, Murray recommended (78) that they be operated in a similar direction. Clockwise movement of a rotary control of an indicator should, Carter and Murray found (7, Chapter 10), be associated with downward and left-to-right movement of the indicator.

In a different experiment, Warrick discovered that clockwise rotation of a control knob should be associated with movement of an indicator toward the operator and from right to left (107, Chapter 9).

Mild anoxia (the condition resulting from lack of sufficient oxygen) seemed not to affect the number of illusions under experimental conditions reported by Grether, Cowles, and Jones (40, Chapter 19). The errors made by a pilot in reading instrument dials tends to increase in the presence of moderate *G* force, as indicated by Warrick, Nelson, and Lund (107, Chapter 20).

On the basis of an investigation of ability to reproduce pressures, Jenkins concluded (54, Chapter 12) that a wide range of pressures from five pounds up to thirty or forty pounds should be required in the operation of airplane controls. Pressures greater or less than those limits seem to be more difficult to reproduce accurately. According to Van Saun (104), for radar operators the polar-grid sector scope was superior to the cartesian-grid sector scope. Both scopes were more readily interpreted when the PPI scope and the sector scopes had the same orientation.

Important contributions were made by psychologists to the design of equipment for flexible gunners and to the technics used in sighting and aiming. Some of these have been mentioned previously in this chapter; others were discussed by Vallance (103, Chapter 14).

Motion-Picture Testing and Research

A complete report of the work on motion-picture testing and research in the AAF Aviation Psychology Program was provided in the volume edited by Gibson (36). Some special aspects of the work have been mentioned previously in this chapter in connection with topics to which they are relevant; other aspects of the work will be summarized in this section.

The history, functions, and personnel of the Psychological Test Film Unit were first published in the *Psychological Bulletin* together with the hypotheses to be tested, research work under way, and test-construction technics employed (90). Gibson wrote more fully on these topics (36, Chapter 1). The peculiar characteristics of motion-picture tests and the unique possibilities of their application to psychological testing were discussed by Gagne, Bornemeier, Gibson, and Borin (32). Many practical problems in constructing and producing motion-picture tests were reported by Gibson, Bornemeier, Eisenberg, and Slater (36, Chapter 3). Some of the problems confronted in the presentation of motion-picture tests were mentioned by Finney and Gibson (21). Experimental evidence of the effects of varied amounts of illumination and of seating position on the perception of motion pictures was obtained. More theoretical were Gibson's discussion (36, Chapter 8) of the differences between the perception of pictures and the perception of visual realities and Gibson and Glaser's formulation (36, Chapter 9) of a systematic theory to account for observed data regarding individual ability in monocular space perception. Further research in the perception of space is needed, according to the authors.

Implications of Psychological Research in the AAF Aviation Psychology Program

It has been impossible to include in this chapter all of the articles concerning the applications to psychological and educational research of work done in the AAF Aviation Psychology Program, but a great many references have been reviewed.

Flanagan discussed general contributions of the AAF Aviation Psychology Program to the theory and knowledge of individual differences and trait differences (25, Chapter 9). Considerations pertaining to the trait theory of human abilities, the measurement of traits, the significance of motivation, and the nature and significance of personality factors were taken up. Of special interest to educators was Flanagan's statement of the implications of research in aviation psychology regarding the nature and principles of learning, the relative importance of aptitude and training, and the measurement of success (25, Chapter 10). The procedures utilized in the AAF Aviation Psychology Program for the measurement of achievement and the prediction of human behavior will be of interest to research workers in psychology and education. Flanagan has discussed these along with the statistical technics and experimental methods employed (25, Chapter 12). He has also commented on several types of research studies leading to the design of equipment for maximum efficiency (25, Chapter 11). Altho to many research workers, much of the experimental work on the design of equipment may appear to be elaborate (and, therefore, expensive) demonstrations of the obvious, Flanagan believes that much work will be carried on in this field in the future. It would appear that this is likely, since its application in industrial psychology is clear.

Guilford has published considerable material concerning the general conclusions and implications drawn from testing and classifying aviation cadets in the AAF (43, Chapter 29). The discovery of aptitude and achievement variables was reported (42) and Guilford and Zimmerman (46) listed twenty-seven factors found by centroid analyses of a number of different correlation matrices based on scores from tests administered to highly selected men in aviation-cadet training. The factors have been identified subjectively by the authors and their co-workers in the AAF Aviation Psychology Program. In the case of ten of these factors the authors believe the names chosen for them may be reasonably accurate descriptions. The practical value of well-established psychological principles was demonstrated during the war, in the opinion of Guilford (43), who drew some lessons from aviation psychology. In another publication (44), Guilford mentioned findings that confirmed long-established principles of test theory; namely, that test validity coefficients are more important than test reliability coefficients for evaluating tests and that the value of a test for multiple selection should be judged in terms of its unique contribution to accuracy of prediction rather than in terms of its validity coefficient. There will be general agreement on these points, but whether factorial analysis provides the means of reaching the desired objectives may be a matter for further discussion among test technicians.

Davis prepared for a commission of the American Council on Education a brief description of the selection and classification procedures used in the armed forces together with their implications for civilian education (15). He indicated that the technics for selecting and classifying aviation cadets in the AAF Aviation Psychology Program constituted the first practical demonstration of the principles that are likely to form the basis for soundly conceived instruments useful in educational and vocational guidance in the future. For differential selection and classification of personnel it appears likely that tests will be developed to measure the variance common to the several criteria to be predicted and to measure separately the variance that is unique to each one of the criteria. The relative weighting of the tests measuring common and unique variance will depend on the proportion of the available manpower that can be rejected entirely. To secure measures of unique variance in each criterion it is not enough to make use of tests that are merely independent; in practice, such tests will probably be constructed by correlating individual test items (that measure as nearly as possible only one mental function and that are maximally reliable) with each one of the criteria to be predicted and building up groups of items that have correlations as high as possible with one criterion and as low as possible with all other criteria. This is the logical extension to test construction for purposes of differential classification of the principles employed to construct the *Aviation Cadet Qualifying Examination* for purposes of selection alone.

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CHAPTER IV

The Personnel Research Program of the Adjutant General's Office of the United States Army

E. DONALD SISSON

THE CONTRIBUTIONS of the Personnel Research Section of the Adjutant General's Office in World War II are reviewed in this chapter. This program was established in 1940 in the Adjutant General's Office with the advice of the Committee on Classification of Military Personnel of the National Research Council. This Committee, of which W. V. Bingham was chairman, included C. C. Brigham, H. E. Garrett, L. L. Thurstone, L. J. O'Rourke, M. W. Richardson, and C. L. Shartle.

The six main sections of this chapter present the work of the staff of the Adjutant General's Office on selection (I) and classification (II) procedures, training (III), the measurement of proficiency (IV), leadership (V), and tabulating and analysis technics (VI). Since the contributions of this group in the form of numbered pamphlets in the Personnel Research Section Report series are anonymous, the individuals who served on this staff from 1940 to 1946 are listed in the accompanying footnote.*

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* Sidney Adams, Earl Alligaier, Jane M. Allison, Carl L. Anderson, Kenneth Ashcroft, Donald E. Baier, Melvin H. Baumhofer, Harold Bechtoldt, Roger M. Bellows, Albert H. Berg, Harold C. Bingham, Walter V. Bingham, Ruth Bishop, Reign H. Bittner, Edward S. Bordin, Hyman Brandt, Louis J. Braun, Robert E. Breden, Hubert E. Brogden, Keith L. Broman, Emma E. Brown, Harry W. Bues, James W. Burns, James W. Campbell, Launor F. Carter, Frank C. Cassens, David J. Chesler, Charles L. Christiermin, Ruth D. Churchill, Kenneth E. Clark, Vernon E. Clark, Earl A. Cleveland, Charles W. Collins, Clyde H. Coombs, Herman A. Copeland, Horace H. Corbin, Robert E. L. Crane, G. Hamilton Crook, Edith Cummins, Edward E. Cureton, Manuel M. Cynamon, Karl M. Dallenbach, Tamara Danish, Jeanne C. Davis, D. M. Depew, Helen C. Dondy, Mitchell Dreese, Hilda F. Dunlap, Walter N. Durost, Robert F. Earhart, Jane L. Eastman, Marian B. Eller, Alvin C. Eurich, Solomon D. Evans, Dorothea W. Ewers, Ray Faulkner, Forrest Forcum, Fred C. Ford, Douglas H. Fryer, Richard H. Gaylord, John H. Glass, Eleanor W. Gluck, Norman I. Greenfield, Winslow Hallett, Wilfred Hamlin, Paul J. Hansen, Thomas W. Harrell, Wells Harrington, Edwin R. Henry, Betty B. Hemmelman, Charlotte G. Honig, Reuben Horchow, Reuben S. Horlick, Robert Iglehart, Mary C. Jarrett, Donald M. Johnson, Thornton C. Karlowski, Raymond A. Katzell, Walter Kelly, William M. Kephart, Philip M. Kitay, Richard Klamon, Celia M. Klinger, David R. Krathwohl, William C. Kvaraceus, Russell G. Leiter, Harry Levtow, Sidney Lind, Floyd H. Lofquist, James M. Lynch, Grace E. Manson, Stanley C. Markey, Dorothy Mathis, Harold McAdoo, Gordon L. McDonald, Joseph L. Melcher, Marilyn R. Mendley, Gerard S. Napoletano, Belford B. Nelson, Philip Nogge, Margaret Norgaard, Bernice Orshansky, Joseph V. O'Rourke, Stanley W. Osgood, Charlotte M. Panimon, Richard H. Paynter, Ruth A. Pedersen (Miss), Edwin B. Petersen, Watson O. Pierce, Adam Poruben, Jr., Bronson Price, Barbara M. Quiat, Evelyn Raskin, Arthur E. Rasmussen, Mary K. Reddington, Prentis Reeves, Alexander B. Reid, Marion W. Richardson, Carmeline Roman, Edward A. Rundquist, James T. Russell, Willis C. Schaefer, William A. Schraeder, William J. Schulz, Janet B. Schwinger, John F. Scott, Robert B. Selover, William Shanner, James U. Shea, Winifred Shepler, Edward M. Sherbourne, Morton A. Siedenfeld, Meyer S. Siegel, Clement H. Sievers, Catherine Romano Sisson, E. Donald Sisson, Charles P. Sparks, Joseph L. Speicher, Naomi S. Stewart, Philip M. Stone, Ralph J. Strom, Margaret Strong, W. S. Studdiford, Calvin W. Taylor, E. K. Taylor, Helen D. Telford, James D. Teller, John T. Thomas, Robert M. W. Travers, Otis C. Trimble, Lillian E. Troll, Read D. Tuddenham, Harold S. Tuttle, Howard F. Uphoff, Arnold R. Verduin, Edgar G. Virene, Virginia W. Voeks, Florence S. Volkman, John L. Wallen, Arthur C. Ward, Robert J. Wherry, Miriam Whintrop, Lawrence Whisler, Carlton E. Wilder, Louis P. Willemin, John M. Willets, Nannie Mae Williams, William R. Wilson, Beryl B. Wisman, Louise R. Witmer, Kenneth Wood, Sarah Zakin, Edwin Ziegfeld, Ernest H. Ziegfeld.

I. Selection

Induction Standards

The differentiation of those who could learn to be proficient soldiers in a reasonable length of time from those of insufficient learning capacity for such service was a preliminary necessity in the utilization of manpower in the war effort. In order to distinguish enlistees who could learn duties of a soldier in the usual amount of time *(Army General Classification Test Grade III)* from slow learners *(Army General Classification Test Grade IV)*, *Classification Test R-1* was developed (35) from *AGCT-1a* items with item-grade correlations of .35—.65. It was standardized (61) in June 1941. Critical scores equivalent to *AGCT* standard scores of ninety and one hundred were derived. Another form, *R-2*, was prepared from *AGCT-1b* in February 1942 (106), and similar critical scores established (119). Forms *R-3* and *R-4* were ready in May 1946 for use with men enlisting or reenlisting in the Army, and the relationship of these forms to *AGCT-3a* was studied (310). Placement and achievement tests in reading and arithmetic were constructed (254) for each of the four levels of training given in Special Training Units (STU) which were set up to teach illiterates possessing learning ability. Preliminary research was extensive; experimental forms were studied for item content, item-analyzed for difficulty, and validated. Standard score scales were constructed for these tests (250, 251).

Literacy Tests. Attempts were made to determine minimum literacy requirements for acceptance for induction, and to develop measures of mental capacity not dependent upon higher literacy levels. Minimum literacy tests were constructed early in 1941 to eliminate those unable to read at the fourth grade level. Critical scores were determined (56) using the *Metropolitan Advanced Reading Test,* Form A, as the reading ability criterion. *Minimum Literacy Test* (Form 1) scores of engineer trainees at Ft. Belvoir in August 1941 were studied in relation to ratings of unsatisfactory, satisfactory, and outstanding on fourteen criteria obtained from training records (55). A tetrachoric r of .45 between those passing and failing the test and the percent above and below the median training rating indicated some relationship between success on literacy test and success on "job." A sharp increase in the percent of unsatisfactory ratings below fourth-grade level indicated this minimum reading ability was a reasonable critical level. Two forms of a verbal measure of general learning ability, *Qualification Test Q-1* and *Qualification Test Q-2*, were released in June 1943, replacing the "pure literacy" test. Each test contained items on paragraph reading, arithmetic computation, and general orientation. Critical scores were established by which men were accepted, rejected, or assigned to special training. The percents of 3311 men tested in induction centers in three service commands scoring in the critical score intervals were tabulated (212, 242). The relationships of Q-1 and other tests to level of training in Special Training Units were studied (192) in September 1943.

Nonverbal Group Mental Ability Tests. Visual Classification Tests VC-1, X-1; VC-1, X-2; VC-1, X-3; and *VC-1a* were nonlanguage tests constructed to select a quota of illiterates with sufficient mental capacity to absorb army training. The item types included visual perception, paired comparison, and abstraction. Revised forms were developed from item analyses of the preceding forms (137, 157, 158, 160). *VC-1, X-2* was standardized on a population of 764 men containing Negroes and whites in a ratio of approximately five to one (138). A lower critical score was set to exclude the lowest 2 percent of the Army *GCT* population, an upper critical score corresponding to an *AGCT* standard score of sixty—Grade IV.

Individual Tests of Mental Ability. The *Wechsler Self-Administering Test* was found too difficult, with too narrow a range of scores among low-grade men. Study and item analysis (112) in March 1942 showed correlations of .83 with the *AGCT* for unrestricted range of 1250 men and .23 for restricted range of 375 low-grade (Grade V on *AGCT*) men. Its validity as a predictor of soldier performance ratings in Special Training Units was very low (218). Low correlations with these ratings of other Army induction tests (216), suggested the possible inadequacy of ratings.

Over-All Studies. In validation studies (test scores with ratings in Special Training Units) of groups of tests (209, 210, 211, 213), the tests with some verbal component were better than the others in screening the unsatisfactory STU men. Biserials between test scores and rejection after STU training or graduation ranged from .38 to .72 for the tests in use December 1943 to February 1944 (214). Various combinations of tests gave multiple correlations well above .60. *Qualification Test Q-1,* dependent to some extent upon literacy, was the best predictor. Standardization data (215) were obtained on three tentative test batteries. The results of the new induction program in June 1944 showed higher rejection rates than the old programs—approximately a 3.5 percent difference each month (242). Also, the educational inferiority of the southern selectee was evidenced by comparative rejection rates of Negroes and whites.

Recruiting Standards for the Women's Army Corps (WAC). Several mental alertness tests were developed for selecting women for the WAC. *Women's Classification Test WCT-1, X-2* (first designated *Mental Alertness Test MAT-1, X-2*), used in the selection of both enlisted women and officer candidates, was standardized (150) in 1942. The test had a Kuder-Richardson reliability of .94 and correlated highly with the *AGCT*, *Otis Group Intelligence, Otis Self-Administering,* and the *ACE* tests (150). A revised form, WCT-2 used only to select enlistees had a Kuder-Richardson reliability of .97 and correlated .85 with the *AGCT* (199). It was standardized (202) on 12,000 applicants in October 1943. WCT-2 was superior to the *AGCT* in predicting academic grades in WAC officer candidate school, but neither of the tests predicted leadership ratings (191). In 1944 a short recruiting test, *Classification Test R-1,* replaced WCT-2. R-1, which has also been used for regular Army recruitment (v.s.) had a reliability of .94 and correlated .78 with WCT-2 (197).

Selection for Specialist Training

A meteorology aptitude test was used by the Air Corps thru the war for the selection of weather observer students. This test battery, consisting of a mental alertness test of the traditional type and fifty meteorology and 144 physics true-false items, gave adequate validities and reliabilities (231). *Aircraft Warning Aptitude Test TC-10A* contained a section on locating grid points by coordinates and a section on plotting coordinates. The first part proved valid against the criterion of theoretical grades in courses, the second part against performance grades. *Aircraft Warning Classification Test TC-11a* was given to those who passed the previously mentioned test for classification into potential specialist categories. More than 90 percent of failures were eliminated (226). Among the specialized tests used in small, sometimes unsuccessful, programs to select trainees for highly specialized Army courses, were those for Balloon Barrage courses (129), Combat Intelligence courses (181, 196), Military Police courses (171), and Medical Technicians (162). A battery including the *AGCT* and several mechanical aptitude tests was investigated for use to select Air Corps bombardiers and navigators. Paper-and-pencil tests were found to be related (73) to academic course grades but not to flight-training records. However, reliability of the latter criterion was low. Research in this area was subsequently transferred to the Air Surgeon's Office in December 1941. A large-scale comparative study of apparatus and written tests was conducted for the purpose of validating and standardizing an aptitude testing program for Air Corps basic-training centers. The written tests were generally superior to the apparatus tests against the criterion of academic success in training courses (227, 228, 229). Tests finally chosen for the battery contained only two performance tests out of a large number tried: (a) *Nut and Bolt Manual Dexterity Test TC-5a*, and (b) *U-Bolt Assembly Test TC-6a*. An attempt was made to validate the instruments against on-the-job performance as judged by five types of supervisory ratings of Air Force ground-crew men in active units. The written tests showed lower validity than with the criterion of academic success. All validities were much lower than in unselected, untrained populations (290, 291). The *U-Bolt Assembly Test* appeared to be of some promise. Tests of informal information in shop mechanics, automotive and driver information, electricity, and radio, originally intended for use together with the latest form of the *AGCT* to form a comprehensive basic classification battery in initial processing, have instead been adopted for use at training centers to select men for specialized training. Two forms of the *Automotive Information Test* (*AI-1* and 2) and of the *Shop Mechanics Test* (SM-1 and 2) have been standardized on large populations (252). Extensive item analyses and validity studies of all four tests have also been conducted (228, 236, 280, 281, 282, 283, 284), with adequate validities obtained. A preference record and a self-description form based on the forced-choice technic were validated against a production index and a 3-point rating in a study of selection instruments for personnel suitable for recruiting work (289), with disappointing results.

Radio Code Operators. Investigations by the Personnel Research Section and various other agencies have resulted in the authorization for Army-wide use of two tests for selecting radio code operator trainees. Many other code aptitude tests have been considered. The criteria used for the validities reported here include number of hours to reach specified receiving speeds, final code speed attained, and the NDRC *Code Receiving Tests.* Usually, several of these were considered in each study (15). The *Signal Corps Code Aptitude Test (SCCA)* evolved from a test tried out by the Signal Corps between 1924 and 1931. By 1941 the *SCCA* was widely used by several of the Arms and Services. Usually administered by phonographic transcriptions, the *SCCA* was a code discrimination type test containing seventy-eight pairs of patterns to be identified as "same" or "different." Reliability estimates by Kuder-Richardson Formula No. 21 were much lower than desirable, ranging from .67 to .78, except for one sample for which .88 was reported (60, 91, 140, 184, 195). Validity data varied considerably from one sample to another, with coefficients from —.03 to .57 (18, 60, 83, 92, 139). Data reported by the Signal Corps for testing between the wars gave validities ranging from .54 to .75 (105). Little improvement in reliability or validity resulted from doubling the *SCCA* to make the *Radiotelegraph Operator Aptitude Test ROA-1, X-1,* which was authorized for Army-wide reception center use in July 1942. The Kuder-Richardson reliability was .87 and reliabilities by the split-half method ranged from .73 to .82 (146, 184, 195). Validity of *ROA-1, X-1* was only fair, usually around .30 (161, 186, 195, 224). The test was standardized on the basis of *SCCA* results, standard scores being set to a mean of 100 and a sigma of 20 (102). Studies indicated that previous musical instrument experience as well as code experience were positively related to radio code test scores and added to success in radio code training (60, 184). Data from numerous radio operator specialist schools indicate that fewer failures result if men are preselected on *ROA-1, X-1* plus *AGCT* rather than *AGCT* alone (224). *Army Radio Code Aptitude Test, ARC-1,* a code learning test developed by The National Defense Research Council (18) took the place of *ROA-1, X-1* toward the end of 1944. The test required the recognition of three learned Morse Code letters when presented with unlearned characters. Validities for *ARC-1,* usually between .50 and .60, were higher than those for *ROA-1, X-1* or the *Thurstone Code Aptitude Test* (224). A check on the standardization sample resulted in the raising of raw score equivalents for the various standard scores (248). A series of *Code Learning Tests,* work-sample tests based on the same principle as *ARC-1,* showed considerable promise but were never carried to the completion stage. Reliabilities by Kuder-Richardson Formula No. 21 and by estimation from odd-even correlations ranging from .94 to .98 have resulted for various editions of the test (65, 91, 128, 140, 161). Validities have, in general, been as good as for either the *ROA-1, X-1* or *ARC-1* (65, 140). A paper-and-pencil alphabet-symbol *Substitution Test-1, X-1*, also developed by the Personnel Research Section, gave reliabilities over .95 but was somewhat less valid than *ROA-1, X-1* (128, 140, 161). A revised edition of a *Code Rhythm Test* developed by Thurstone has also shown some promise (105, 128). The *Thurstone Code Aptitude Test* was tried out in studies on *ARC-1* and a revision of this test, designated *ROA-2, X-1*, was accomplished (205). Both tests were highly reliable but the original Thurstone test was more valid.

Truck Drivers. Research resulted in the standardization and validation of a group of tests (16), including a *Driver Experience Inventory*, a *Driver Information Test*, tests of visual acuity and night vision, and a reaction-time test. Other well-known psychophysical tests were assessed as predictors of driving ability. Most frequent criterion was a road test, consisting of fifteen to twenty minutes observation of driver in the standardized situation. Specific tests were checked on a *Road Test Check List*. A score consisting of checks of correct or incorrect operations, weighted or unweighted was obtained, plus an over-all rating. Reliability coefficients for the road test were not as high as those usually obtained for objective tests, but equalled those usually obtained for criteria in validity studies (24, 64, 72, 86, 126). Two forms of a *Driver Information Test (DIT)* were standardized (172, 176). Trial of personal history items showed driving experience items to be most valid (25, 72, 123, 134, 152). A *Driver Experience Inventory* showed variable validity, fairly high in certain populations (120, 147, 172).

Visual Acuity. Several of the more familiar visual acuity tests gave consistently low correlations with the road test (25, 72, 126). Tests of night vision gave higher validities against a special night road test (71, 76, 131). Studies of race differences in night vision (25, 78, 121) produced no consistent or significant results. High sugar intake showed no effect on night vision (72). Studies are currently in progress on the standardization of new tests of visual acuity and night vision.

Sensori-Motor Tests. Data show low positive and zero correlations and some inconsistency from sample to sample in studies of several sensori-motor tests as predictors of ratings of driving ability. However, populations were often small and criteria not always reliable. In addition, soldiers are already a physically selected population (25, 71, 126).

Trade Knowledge Tests

Numerous editions of tests in electricity, radio, and automotive mechanics have been developed to aid in the identification of those with interests and aptitudes in these fields, as evidenced by possession of informal information. A *General Electrical and Radio Information Test* was constructed after item analysis of experimental forms (100). Subsequently, separate series in electricity and in radio were established. Limited analysis revealed some fair validities (227, 239). A *General Automotive Information Test* yielded a correlation of .67 with course grades of 147 men (110). The test was further expanded and item analyses and additional validity studies were carried out (122, 142, 169, 183, 239).

West Point Qualifying Examinations

Each year since 1942 a new form of *West Point Qualifying Examination (WPQ)* has been constructed for administration along with the regular West Point examinations. It is intended that this battery eventually replace present West Point entrance examinations. The latest form of the *WPQ* contains two subtests, *Language Aptitude* (learning an artificial language), and *Elementary Mathematics* (the use of short-cuts in arithmetical and algebraic processes). Each year's series was tried experimentally and prevalidated on classes already selected and attending the Academy and administered in final form to applicants the following year. Additional validity data were gathered subsequently, with academic success as criterion (164, 174, 182, 190, 219, 220).

Selection of Warrant Officers

Objective examinations have been developed in over thirty administrative and technical military specialties for the selection of warrant officers. The subjects range from Auditing and Accounting to Weather and Cryptography. No reliability or validity data have been gathered on these tests, altho they were constructed with the aid of technical experts and have been widely used (237, 275, 276).

Personality Studies

In 1942, Personnel Form P-1, also known as the *Shipley Personality Inventory*, was proposed as a group test for military use in differentiating troublemakers, neurotics, and normals. Extreme troublemakers and extreme neurotics were identified by this instrument (149), but reliability (136) was very low. More intensive research in personality measurement by the Personnel Research Section was begun toward the end of 1943. The *Minnesota Multiphasic Personality Inventory*, adapted and revised for Army use, the *Cornell Selectee Index*, the *Army Individual Test* (See Chapter II), and the *Biographical Information Blank* (See Chapter VI) were among the instruments studied (61). The *Multiphasic Personality Inventory*, a paper-and-pencil objective test, scored separately for each of nine psychiatric classifications, showed promise; its items were analyzed and some selected (294) for inclusion in the *Biographical Information Blank* used in the regular army officer retention program (See Chapter II). Validity studies of the *Multiphasic Inventory* were made in connection with predicting AWOL's and psychiatric referrals among basic trainees, predicting psychiatric rejects among WAC applicants, selecting trainees for Arctic duty, and validating against careful psychiatric diagnoses. Results have been favorable enough to justify further study and development of the inventory. An item analysis of responses of "good" and "bad" WAC applicants did not show significant differences (314). Correlational analyses of the *Army Individual Test*, composed of six separate subtests and administered to a population of psychoneurotics and psychotics, suggested the validity of the *AIT* for differentiating between psychoneurotics and specific psychiatric diagnostic categories, particularly when products and squares of test scores, rather than sums and differences, were used (313). The Army Wechsler subtest scores were found to add little to predictions.

II. Classification

The Army General Classification Test

The *Army General Classification Test* (3, 7), providing an index of the learning ability of recruits to facilitate classification for training and job assignment, was first released as *AGCT-1a* in October 1940. Subsequent forms, including two Spanish versions (258), were issued during the war: *AGCT-1b* in April 1941; *1c* and *1d* in October 1941. These consisted of 140 to 150 multiple-choice items on vocabulary, arithmetic, and block counting. Raw scores were converted to standard scores with a mean of 100 and a standard deviation of 20. Standard scores were divided into five Army Grades. A revised series, in which part scores were recorded for the first time, appeared as *AGCT-3a* in April 1945 and *AGCT-3b* in 1946 (236, 278). The *AGCT-3* series contained four tests: reading and vocabulary (189), arithmetic computation, arithmetic reasoning (235), and pattern analysis. The total score was the equivalent of the *AGCT-1* score while part scores were also used in classification. An information battery, originally intended for inclusion in the *AGCT-3*, was used instead for classification purposes at training centers. Four forms of each type of subtest in the *AGCT-3* were developed and equated for content and difficulty.

Standardization. Standardization of *Form 1a* (31) was accomplished, before the first inductees under the Selective Service Act entered the Army, on a population of regular Army and CCC men equated to the expected Army population by weighting on age, education, and area of residence. Due to several other factors which could not be taken into account, e.g., race, occupational deferments, illiteracy, direct commissions, the distribution curve of the actual Army population varied from the expected. Despite this variance, the conversion table for *Form 1b* (40) was computed by combination regression of *1a* and *1b* scores, because the norms for *1a* were already widely used for classification. Standardization of *Forms 1c* and *1d* (42) was based on *1a* and *1b*. Distributions on *Forms 1c* and *1d* had less negative skewness, and the conversion tables were set up to yield

Army grade percent midway between the old and the new forms. Improved discrimination of *1c* and *1d* was partly due to more equitable distribution of item difficulty. *Form 3a* was standardized (236) on a population of 39,000, carefully stratified and weighted by age, education, race, and geographical location.

Item Analyses. Studies of response frequencies, item difficulty, discriminating power, and item-test consistency (29, 30, 35, 41, 115) were used for guidance in construction of alternate forms. It was found that equal scores might represent widely differing performances in type of questions answered (143, 117). Most extensive item analyses were made on the four trial forms for the *AGCT-3* (236). Final form items were carefully graduated in difficulty and selected on the basis of item-total test correlation.

Practice Effect. Study of practice effect on *1a* and *1b* scores (39) and *1c* and *1d* scores (42) showed small but consistent increases regardless of which form was taken first. Retesting after considerable lapse of time for Grade V men (173) and men in OCS (163) showed similar results, which were attributable to factors other than the effects of Army training.

Part Scores. Altho part scores of the *AGCT-1* were not used for classification, investigation was made of relative contributions, discriminative power, intercorrelation, reliability of parts, and correlations with part and total scores of other forms (36, 38, 114). Each part was found to make a significant contribution. Combined vocabulary and arithmetic scores of one form were found as good as total scores for predicting total scores on a second form.

Reliability. Repeated reliability estimates on all forms by Kuder-Richardson Formula No. 21 (31, 40, 42, 236), odd-even comparisons (31), retest (75), alternate forms (38, 42, 236), and Kuder-Richardson Formula No. 2 (236) placed the reliability generally above .90.

Validation. Several hundred validity coefficients attest to the value of the *AGCT* in selecting men for a large number of Army specialist courses (27, 37, 57, 68, 73, 77, 89, 92, 94, 97, 99, 108, 113, 129, 132, 174, 175, 176, 178, 201, 213, 223, 226, 277, 324, 336, 338). Most of the populations were preselected either on the *AGCT* or on some highly correlated factor. The criterion was usually academic grades. Where preselection was rigorous, correlations were lower. Validities for criteria involving personality, e.g., success in Officer Candidate School (99, 132, 175, 198), or formal academic background, e.g., success in the Army Specialized Training Program (324, 336, 338), are low. *AGCT-3a* (227) was generally superior to *AGCT-1.* The reading and vocabulary subtest correlates highest with written examinations, and pattern analysis is usually the best predictor of practical performance. Use of part or combined subscores in classification is questionable because of high subscore intercorrelations.

Relationship with Other Variables. Studies show high correlation with education (31, 118, 127, 136, 270) and with other well-known tests of mental ability (32, 34, 103, 104, 165, 257, 331), decreasing with restrictive preselection, but no significant relationship with age (31, 118, 236), except that in highly selected groups, correlations tended to be slightly negative. Comparisons of male and female Army populations in age, cultural and educational background, selection methods, and geographical distribution, had inconclusive results (236). Comparisons of Negroes and whites (117, 270), complicated by social, cultural, and educational differences, showed lower mean scores for Negroes, the difference decreasing where educational status was matched. Mean scores for northern soldiers of both races are higher than for southern soldiers of the corresponding race. An early tentative study of relationship to civilian and military occupations (26) was made. Later studies showed a definite occupational hierarchy and sectional differences within occupations (270), despite considerable overlap, even between highest and lowest ranks; but no relationship to age or experience was found. Variability of scores was higher in lower level occupations. Occupations with restricted score ranges probably depend on abilities measured by *AGCT;* others with wider ranges depend more on specific interests or aptitudes. For counseling purposes a low score was considered possible ground for avoiding a high level occupation, but a high score per se is no ground for avoiding any occupation.

Special General Classification Tests. A special *Non-Language Test 2abc* to test illiterates and Grade V men was standardized (59) on a population with a normal distribution of *AGCT* scores. An *Army Individual Test (AIT)* of general mental ability (16, 17) consisting of three verbal and three performance tests (221, 222) was standardized (230) on a group of 1000 native-born literate whites. A study on a small population (222) indicated that the test could discriminate between Grade V men in Special Training Units who were likely to succeed or likely to fail in Army training.

The Mechanical Aptitude Test (MAT)

The general *Mechanical Aptitude Test MA-1* appeared in February 1941. *Forms MA-2* and *MA-3* were released in October 1941. A later form, *MA-4, X-1*, was built for WACs. *MA-1* consisted of items on mechanical movements (54), surface development, and shop mathematics. *MA-2* and *MA-3* differed considerably from *MA-1*, containing mechanical information (23, 53), mechanical comprehension (51, 50), and surface development; of which the first two were found to be good predictors for mechanics courses (58). *MA-4, X-1* contained items on tool recognition, mechanical comprehension, and surface development. Use of the *MAT* at reception centers, where scores were recorded for all except illiterates and Grade V men on the *AGCT*, continued until April 1945. It was supplanted by the *AGCT-3a*, which contains a surface development section similar to the *MAT*. Thereafter the *MAT* was used whenever deemed advisable at training centers.

Standardization. MA-1 was standardized on 3452 men (47). Standard scores, with a mean of 100 and a sigma of .20, were calculated by equivalent percentiles yielding a breakdown in five Army grades which approximated a normal distribution. *MA-2* and *-3*, based on item analysis of trial forms (70, 82), were standardized (90) by equivalent percentiles for *MA-1* scores on a population of 2766 men. *MA-4, X-1* was standardized by linear transformation (154), and was item analyzed (180).

Reliability. Estimates by the Kuder-Richardson Formula No. 21 (46, 47, 90, 154), test-retest method (49, 163), and equivalent forms method (90) show satisfactory reliabilities for both total scores and subtests.

Validity. Validity studies gathered a wide range of correlations, usually lowered by preselection, with course grades and other criteria. As a verbal test, the *MAT* correlates best with theoretical course grades (66, 227) and motor mechanics (48, 49, 89, 97, 103, 125); less well with driver performance ratings (156, 172); and negligibly with radio code receiving speed (84, 201, 205). Varying results were obtained for clerks (94), aircraft warning operators (226), airplane mechanics (194, 201, 228, 229), basic trainees (68), and Navy trainees (52, 129). Validity of *MA-4, X-1* with WAC specialist school grades as criteria (186) was superior to the *AGCT* for motor transport, but inferior for radio repair school. A study of *MA-4, X-1* for civilian armament trainees (239) found that its validity would be improved if the *Surface Development Subtest* were omitted.

Relationship to Subtests and Other Tests. MA-2 and *MA-3* were found to be superior to *MA-1* in being less highly correlated with the *AGCT* (47, 69, 87, 90, 95, 96, 226). Intercorrelations of total scores and subtests were high (47). Correlations were computed for the *MAT* and civilian mechanical aptitude tests (49, 52, 226, 227).

Tests of Mechanical Aptitude for Civilians. A provisional battery, *Mechanical Aptitude Test MA-5*, was not as valid as standard civilian mechanical tests (250). A mechanical aptitude battery consisting of *Learning Ability Test LA-5* (an Air Corps test of mental ability), *Tool Usage, Mechanical Problems*, and *Paper Form Board Test CG-106a* did distinguish mechanics from nonmechanical workers (260). *General Mechanical Aptitude Test CM-142a* yielded fair correlations with both final mechanical grades and supervisors' ratings (263). A revision of this test, made shortly after V-J day, was designated *CM-142ar* (264).

Clerical Aptitude

Clerical Aptitude Test CA-1, completed in 1940, consists of 280 items on name checking, coding, catalog numbers, verbal reasoning, number checking, and vocabulary. It was standardized (20) on a group normally distributed by *AGCT* scores. Resulting distribution (63) was leptokurtic for both the standardization sample and field returns. Reliability by Kuder-Richardson Formula No. 21 was .95 (20), by test-retest method .72 (163). Validity coefficients are usually based on small populations, the criterion being clerical school grades (19, 47, 69, 94, 96). Since it is highly correlated with the *AGCT* (21, 47, 69, 94, 96) and sometimes inferior as a predictor of clerical grades to the *AGCT*, the *Mechanical Aptitude Test* (94), or the Wells Revision of the Army Alpha (19) its usefulness has been questioned. Experimental material for an uncompleted alternate form of *CA-1* was used in constructing *Clerical Aptitude Test CA-2, X-2* for the WAC, which covered classifying, cataloging, number and name checking, alphabetizing, and spelling. In the standardization the score distribution departed markedly from the normal, and the percentile method was used to set up standard score scales. The Kuder-Richardson reliability was .97 (154, 179). Validity studies (186) with grades in specialist courses as criteria showed *CA-2, X-2* to be inferior to the *AGCT* for administrative specialists. More widely used than any of the above clerical aptitude tests were those developed for civilian employees of the War Department, which in chronological order of use were the *General Proficiency Test WCT-1, X-3* (151, 155); *CA-2, X-2* (179, 185); a provisional battery, *Clerical Aptitude Test CA-3* (261); and finally *General Clerical Abilities Test CC-105a* (241, 247, 262, 292). Part A of *CA-3* correlated .32 with supervisors' ratings in some jobs (233, 240). Parts of *CC-105a* had an average correlation of .35 with Civil Service CAF grade and supervisors' ratings, but in a number of cases reached correlations around .50 (259, 293, 317).

Army Trade Screening Tests

To verify skill status in Military Occupational Specialties a series of *Army Trade Screening Tests* and *Experience Check Lists* in clerical, mechanical, and other technical fields was developed (10, 286, 287, 288). Reliabilities, estimated by Kuder-Richardson Formula No. 4 for eight of the tests, ranged from .87 to .93. Critical scores were set for most of the tests to represent the level of technical achievement attained by graduates of the corresponding Army specialist course. Critical ratios between experienced and inexperienced men were high. Critical ratios dropped when examinees were encouraged to guess.

III. Training

Measurement of Academic Knowledge

Measures of educational achievement in the armed forces gained a new importance with the inauguration of the Army Specialized Training Program. Tests in academic subjects such as Algebra, English, etc. were constructed for the Air Forces (67, 87, 93), Corps of Engineers (68, 116), Coast Artillery (142), and the WAC (170). These tests were used as early selection devices until instruments of better validity were developed. A study was also conducted on the difficulty level and usefulness of a *General Educational Test* for Warrant Officer candidates constructed by the Cooperative Test Service (249).

The Army Specialized Training Program: Selection Tests. At the inception of the Army Specialized Training Program (8) a test constructed for officer candidate selection, the *OCT-2, X-3,* was found useful as a general ability test (318, 319). It was a considerably better predictor of success in basic engineering courses than the *AGCT* (324, 334). For the Army Specialized Training Reserve Program, three *Army-Navy Qualifying Examinations* were constructed by the College Entrance Board for screening applicants (320, 323, 331). A qualifying test *(C-4),* composed of mathematics and vocabulary items, was prepared by the Personnel Research Section for the same purpose, and was found to discriminate satisfactorily (341) among applicants. A *Mathematics Inventory Test,* from which the mathematics section of *C-4* was derived, was used for placement in appropriate curriculums, at the proper level of difficulty, and proved to be a good predictor of success in the ASTRP (340). A series of aptitude tests for professional medical training was also built (328, 329) and their relationship to *AGCT* (325, 326) and other educational factors (330) was studied. Certain achievement tests in mathematics and physics were used as selection devices for some advanced courses.

Achievement Tests. More than 150 different national achievement tests covering at least eight subjectmatter fields (6) were administered in all basic and advanced courses as a check on uniformity of content and adequacy of instruction given in approximately 200 different training units. These included tests for seven different foreign languages. A series of studies recorded reliabilities for the tests (6). Attempts were made to develop valid norms for test scores (322, 332). Item analyses on preliminary forms (327, 337) aided in constructing more reliable forms of the tests. The validity of the tests as predictors of success in basic engineering was investigated (321). Studies of correlations between R and $R\text{-}\frac{1}{3}W$ showed that guessing had little effect on test reliability (333, 335). A socio-economic study (339) determined that 30 percent of the trainees were receiving more education than their prewar plans contemplated. One result of the national achievement testing program was that many instructors who originally opposed objective testing in college courses came to accept its value.

Military Training

A *Military Knowledge Test* consisting of multiple-choice items and organized in pictorial form thruout was developed to test the basic military knowledge required of all soldiers. This test evolved from an item analysis of several experimental forms. It was used as a device to determine whether men being redeployed needed refresher training. The test distinguished trained and untrained infantrymen; however, validities were around .30 against the *Soldier Performance Scale* (See Chapter IV).

Army Automotive Screening Battery. An *Experience Check List,* and *Apprentice Mechanics Test,* a *Tool Usage Film Strip Test,* and *Distributor* *and Valves Assembly* and *Use of Tools* performance tests, administered by the "successive hurdle" method, have been used with great success to screen army automotive students who could bypass elementary phases of training. Based on trial of many experimental forms and methods of scoring, the battery showed high validity (255). A subsequent follow-up study showed that students selected to skip beginning phases of training on the basis of these tests completed the course even more successfully than students taking the entire course (256).

IV. Measures of Proficiency and Criteria

Truck Driving and Machine Shop Performance

Performance criteria for truck driver trainees consisted of a practical road test checklist with objective ratings on specific items and a general driving proficiency rating, usually on a 5-point scale. The reliabilities of road test ratings are as high as those usually available for practical performance criteria. An early attempt at extreme objectification (64) was abandoned because of poor results. In one study the biserial correlation between number of unsatisfactory items on a checklist and general ratings was .83 for 1982 men and .28 for 1454 men rated under somewhat different conditions (72). Weighted checklist scores had tetrachoric correlations between .51 and .82 with general ratings for a sample of 1717 men (86). Other reliabilities are recorded using the split-half method (126) and test-retest method (24) on checklist scores. The general conclusion was drawn that reliability can be increased by training the examiners.

Three raters were used to rate examinees on performance on a list of common machine shop operations. Estimated agreement among raters was fair. Average reliability of all three raters was .80 (107).

Soldier Performance Report

Major use of the *Soldier Performance Report* was as a criterion for predictor tests such as the *Army General Classification Test* and the *Army Individual Test* in an effort to screen potential satisfactory soldiers from poor risks before basic training. Two early experiments (98, 203) were reported. Another study, validating a group of induction station tests (208), used a scale restricted to marginally satisfactory and unsatisfactory ratings. Contingency coefficients of reliability ranged (corrected) between .64 and .78. Somewhat lower coefficients were obtained for a much more restricted group on *AGCT* scores (211). In the validation of induction station tests an 8-point scale and a composite checklist were used (210). To validate a military knowledge test, a soldier performance scale (279), in which a superior noncommissioned officer rated the soldier on a 5-point description scale, showed satisfactory reliability (above .80) by rating and rerating comparisons and correlations between ratings by platoon leaders and platoon sergeants.

AAF Technical School Success

Attempts were made to find criteria more reliable than academic course grades for predictors of success in AAF schools. Paired comparisons (229) showed high reliability for small groups of ratees. Closest approximation to on-the-job conditions was tried (290) on technicians in AAF combat units in the *ZI*. Five types of on-the-job rating were secured: rank in over-all job ability, paired comparisons, and a five-step scale on performance, personality, and over-all worth. Odd-even reliabilities were high except for personality. Intercorrelations were about .90.

War Department Civilian Employees

Dissatisfaction with the reliability of criteria in use for test predictors in clerical work led to some experimental work on supervisory ratings. Two ability rating scales and a trait scale were constructed (293). They showed less correlation with predictor test grades than did civil service grade.

Officer Efficiency

A criterion originally developed to validate devices for measuring leadership and personality fitness among officers became the backbone of several programs of officer selection, retention, and efficiency reporting. The adequacy of the criterion depends on the agreement of groups of officers intimately acquainted with the character and proficiency of given officers as to their placement in widely separated positions along a continuum of over-all competence (343). It was determined that a random group of ten rating officers can distinguish the over-all competence of officers almost as well as can a designated group of ten selected raters. In order that assignment to any criterion group be reliable, the officer being rated should be known well enough to be rated by at least seven out of ten raters. This procedure was perfected in the "Buddy Rating System" (295, 297) in an experiment with Officer Candidate School classes. Pooled independent ratings by a group of "buddies," when checked against ratings by the platoon officer, yielded a highly reliable criterion against which to measure selection instruments. The corrected split-half reliability varied between .81 and .91, and correlations between buddy and platoon officer ratings ranged from .51 to .59. Greater reliability (295) was obtained as length of acquaintanceship increased. A system was devised for assigning a criterion index score of from 0 to 60 to include, in addition to definite criterion groups of high, middle, and low competence, those men of more indeterminate status (298). A variant of the original pooled rating system, comparison of the officer with Army Officers in general and with officers of the same grade on a 20-point scale, was later developed and showed high correlation with the criterion index (266).

V. Studies of Leadership

Officer Selection

Tests, rating forms, officer evaluation reports, interviewing procedures, and other devices were developed and investigated for measuring background, learning ability, and leadership qualities of officers and officer candidates. In 1941 two forms of the *Higher Examination*, *H-1* and *H-2*, containing the most difficult vocabulary and arithmetic items, were constructed. These forms were intended for more exact discrimination among candidates in Army Grades I and II on the *AGCT*. Tables of equivalent scores with the *AGCT* were prepared (74). Both forms correlate highly with each other and with the *AGCT*. Reliability coefficients are high. Undue emphasis on speed caused examinations to be discontinued for officer candidate selection because the speed factor appeared to discriminate against the older men. *Form H-1* correlated .48 with final grades for sixty-seven engineer officer candidates (79, 85, 88). *War Orientation Test, WOT-1, X-1*, containing 100 five-alternative items on information about current events, had high reliability and gave significant differences in means between officer candidates and basic trainees, but had lower validity than the *AGCT* as a predictor of success at Officer Candidate School (153).

Officer Candidate Tests, OCT-1 and OCT-2. Experimental forms contained items on comprehension of paragraphs and graphic material and on arithmetic reasoning, which were chosen from the *Army Officers Training Examination*, a battery developed for the War Department by the Cooperative Test Service. Reliabilities for the first experimental form were not satisfactory but higher correlations with OCS grades were obtained than for the *AGCT* (148). Conversion tables to *AGCT* scores were prepared and an item analysis made (118, 167). The test was rejected because informational content was taken from commonly used War Department manuals. Two final forms, *OCT-1* and *OCT-2*, were constructed after item analysis of two new experimental forms (168) and standardized on 2000 men (175). Reliabilities were .81 and .91 respectively by the Kuder-Richardson Formula No. 21. Both forms correlated highly with the *AGCT* and with years of education in an unselected population. Validity coefficients were high, both tests being far superior to the *AGCT* as predictors of academic success in Officer Candidate School (198).

Leadership Studies. Early approaches were based on analysis of War Department and civilian literature on leadership, management, etc. Two rating scales were developed but not validated. Interview procedures and forms were also developed and analyzed (177). Projective technics were investigated by the administration of the *Rorschach* and *Thematic Apperception Tests*, sentence absurdities, picture absurdities, and *Philo-Phobe* list to fifty-two men. Most correlations with leadership ratings were low. Practical difficulties precluded the use of these instruments on a large scale (177). *Preference Inventory, PL-1, X-1* contained 100 groups of three activities, each presumably preferred by the combat leader, administrative leader, or the nonleader. Correlation with leadership ratings at OCS were insignificant (204). *Leadership Test, L-1, X-1*, requiring judgment in leadership situations, was also discarded (178). Combat reports from the North African campaign and analysis of leadership selection by British and German armies and of civilian research in the United States led to reexamination of leadership selection methods. Suggestions were made by the subcommittee on leadership of the American Psychological Association Emergency Committee on Psychology. Ernest Ligon, Consultant to the Secretary of War, reported on lack of uniformity in current officer selection procedures. A *Combat Adaptability Rating Scale* was used in conjunction with a series of tests including an interview, performance situation, and stress situations. Reliability of ratings was high, but low correlations were obtained between the rating scale and tests (225). No follow-up studies were made of individuals in actual combat because of administrative difficulties.

Officer Retention Program. The largest, most successful, and most revolutionary program in leader selection was worked out for the program of selection from among temporary officers of those to be given permanent commissions and integrated into the postwar regular Army (4). Personnel instruments developed include an *Officer's Application for Commission;* an *Officer Classification Test, OCT-14*, a test of general learning ability of suitable reliability but not adopted for other reasons; a *General Survey Test* of general educational achievement, including material from the fields of English usage, humanities, physical and biological sciences, and social sciences; a *Biographical Information Blank;* an *Officer Evaluation Report*, an improved efficiency rating device; and a *Standard Interview Procedure*, a new type board interview which was objective, reliable, uniform, and completely different from usual Army board proceedings. The *General Survey Test* is used as an initial hurdle, while scores on the *Biographical Information Blank, Officer Evaluation Report*, and *Interview* are combined to yield a composite score indicating over-all fitness. All instruments have been shown to be valid for representative officer samples against rigid criteria of agreement by fellow officers as to each applicant's over-all fitness (13). A general bibliography on leadership was compiled as background for the program (9).

Construction of Selection Instruments. Preliminary forms were tried out on approximately 8000 officers and officer candidates. Two 125-item forms of the *Officer Classification Test (OCT)*, containing sections on reading comprehension, arithmetic reasoning, and interpretation and judgment, were each administered to groups of 500 officers. Two final 110-item forms were constructed on the basis of item analysis (306). A study of equivalence showed appreciable difference between forms (305). *Form A* had good validity for predicting success in technical courses (307), but did not correlate with general criterion of officer competence used in major study (see *Validity of Battery*, below). *Form 1* of the *General Survey Test (GST)* contained 200 items selected from two preliminary forms after item analysis of 1000 cases (306). Percents of applicants selected by various cut-off scores by Arm and Service and educational level were determined (311). The *Biographical Information Blank (BIB)* (297) provided a means for objectively measuring elements of past experience and personal characteristics, experimentally determined to be significant for predicting officer success. *Form E*, the final form used, contained 204 items divided into four parts: eighty-two biographical items, twelve pairs of self-evaluation items, ninety-four officer description items in forty-seven groups, and sixteen multiphasic pairs of items. All technics of personality measurement which had shown promise were investigated and the "forced-choice" technic exploited. Nine types of items received preliminary trial. Self-description items were presented in quintets (295) containing two desirable, two undesirable, and one neutral alternative. The two desirable or undesirable characteristics were equal with respect to degree of desirability, but differed as to relative importance for officer success. Scale values had been obtained previously (296). One hundred ten pairs of items from the *Minnesota Multiphasic Inventory, Form TC-8a*, were tried (294). The criterion for item selection on the *BIB* consisted of "buddy ratings" by fellow officer candidates and a ranking by platoon officers. Reliability of the "buddy ratings" was high. Correlations of ratings with the *AGCT* and education is low, consistent with other studies. Alternatives were then analyzed as to correlations with high or low criterion groups of officers. Various methods of scoring and the effects of various cutting scores were analyzed. Development of an objective *Officer Evaluation Report (OER)* was begun with appraisal of current Army efficiency rating methods. The War Department *AGO Form 67, Officer Efficiency Report*, and the *AAF Form No. 123, Officer Evaluation Report* were subjected to intensive analysis including intercorrelations of sections and trait ratings and factor analysis (301, 302). The technic of collecting statements from officers and enlisted men concerning characteristics of good and poor officers and refining and scaling these statements was investigated (300). Also available were the findings on investigations of the "forced-choice" technic (295, 296). Discriminating power of every item in nine different types of rating scales was determined. The *Interview* is a standardized, objective procedure which breaks sharply with tradition. It is intended specifically to evaluate ability to deal with people. Board members observe behavior and record observations, then check descriptions, integrate these into ratings on specific areas of behavior, and finally evaluate candidate's ability to deal with people. Objectivity was achieved by defining overt behavior that could be observed and judged during the interview and developing conversational situations designed to elicit this type of behavior (299).

Validity and Reliability of the Entire Battery. Two purposes were intended: (a) to select officers who were outstanding in past and present performance of duty, and (b) to assure the ability of such officers to remain outstanding in the future. For achievement of the first aim, scores on the *Officer Evaluation Report (OER)* and the *Biographical Information Blank*

(BIB) for 3000 officers and on the *Interview (INT)* for 1359 officers were validated against job performance as evaluated by a large number of fellow officers. Approximately 13,000 officers were studied for development of criterion groups. Three groups, high, middle, and low, of about 1000 men each were used, consisting of men clearly and consistently placed in these categories by fellow officers in battalions or similar groups and by commanding officers. To achieve the second purpose, scores of 3000 officers on the *General Survey Test (GST)* were compared with educational level attained and scores for 367 officers on the *Officer Classification Test (OCT)* were compared with scores on the *AGCT*. A combined point-index based on the *OER*, the *BIB*, and the *INT* adequately differentiated officers on the basis of efficiency and did so in a manner far superior to the traditional Army board proceedings. Percent of most competent and least competent officers chosen by various cutting scores was determined. Mean score on the *GST* showed a high relationship to educational level achieved and showed high variability at each educational level. All instruments and the criterion were determined to have suitable reliability (298).

New Officer Candidate Program. Instruments devised and validated in the integration program for officers were adapted for selecting candidates for Officer Candidate Schools among enlisted applicants of the Signal Corps (303, 304) on the basis of leadership. An interview procedure, a biographical information blank, a military report, and a recommendation blank were validated against pooled buddy ratings and platoon officer ratings at various stages of training. The *AGCT* and *OCT* were found to be satisfactory predictors of academic success. This work was expanded to include the development of officer candidate selection instruments on an Army-wide basis. Forms used in the Signal Corps study were revised (312) after analysis.

Integration of Nurses into the Regular Army. Items for a biographical information blank (315) and an evaluation report (316) were secured from an analysis (285) of essays on good and poor nurses and from officer characteristics evaluated previously (296).

Officer Efficiency Rating Methods. A thoro research program on officer efficiency reporting methods grew out of the investigation of the usefulness of the semiannual officer *Efficiency Report, WD AGO Form 67*, as a selection device for the retention of wartime officers in the regular Army (298). Five methods were evaluated: the currently used *WD AGO Form 67* (301) and *AAF Form 123* (302); a forced ranking form *FR-2* (272); a report *(OER-A)* using the rating checklist technic (273); and a report *(FCL-2)* using the forced-choice technic (274, 295, 296, 297, 308). These were validated against four separate criteria: (a) Position in criterion groups of high, middle, and low officers as rated by groups of fellow officers (295, 297); (b) a criterion index score of from 0 to 60 based on these nominations (266, 298); (c) an over-all rating on a 20-point scale in comparison with Army officers in general; and (d) comparison with officers of the same grade. Results showed a clear superiority of the *FCL* over the other four instruments (265, 266, 267, 268). In consequence, a revised form, *FCL-3*, was tried with corroborative results (269). Later studies found that validity was increased by combining the rating checklist of the *OER-A* with the *FCL-3* (309), tho the *FCL* alone is superior to the *RCL* alone; that forced ranking as used in *FR-2* increased validity slightly when incorporated with other forms, but had low validity alone; and that indorsement of ratings improved validity slightly (271), but later training had little effect (270).

VI. Tabulating and Analysis Technics

Test Validity

A formula was developed for estimating the reduction in size of correlation coefficient when mean scores are inserted for "no data" cases (234), as well as formulas (207) for estimating change in r and other statistical constants due to selection on a single variable, either predictor or criterion. An empirical study of effects on obtained correlation of restriction in range led to results fairly comparable with predictions on basis of Kelley's formula (95). A method for estimating the probability of obtaining a score at or above the mean on the criterion for any given score on the predictor variable (28) was further developed (144, 145) by a method for estimating the probability that an individual with any given score on the predictor will fall at or above any given critical score on the criterion. The original method was extended to make it applicable to evaluation of significance of differences in test means for two samples (111). Two methods were presented for estimating test efficiency (166). Another approach is given in Richardson's formula (206) for interpreting a test validity coefficient in terms of increased efficiency of a selected group of personnel. A method was proposed for estimating the size of the sample required for test standardization (62).

IBM Equipment. Maximum utilization of IBM equipment and elimination of errors introduced by inaccurate usage were of some concern. An extra circuit added to the test scoring machine will give certain derived scores directly by shifting the zero point (43). Errors result from the use of Government Printing Office Answer Sheets when the test scoring machine is set for IBM Answer Sheets (101). Favorable conclusions were reached concerning possibility of utilizing No. 1 pencils instead of IBM pencils in marking answer sheets (135). Detailed steps necessary in checking the adjustment of the IBM Test Scoring Machine were reported (245). A tabulation was also made (45) of differences in scores between machine-scored and hand-scored answer sheets.

Test Selection. A procedure was developed for estimating the proportion of the variance of the total scores on a test contributed by each of the parts (130). The effect of a suppressor variable upon Wherry test selection results was also discussed (243).

Item Analysis. Tetrachorics were found more reliable than item-test correlations obtained with use of Richardson's Nomograph (80). Errors in the use of Richardson's Nomograph to analyze items not attempted by all subjects were pointed out (44). The effect of guessing on biserial correlations obtained between items and true scores was found to vary with item difficulty (244). Maximum r obtainable with Adkins-Toops Quintile Formula was found to vary with difficulty of item (238).

Test Reliability. Kuder-Richardson Formula No. 21 appears to underestimate reliability of scores based on the average of two administrations. A new formula was suggested (133). Insofar as assumptions underlying Kuder-Richardson Formula No. 21 are met, the addition of zero scores will increase the magnitude of the N obtained for all r's less than unity (81). Kuder-Richardson Formula No. 20 appears to overestimate the reliability of a test when the distribution of item difficulty is highly skewed (200). A technic was given (200) for computing practice effect, difference in difficulty of parallel forms, and difference in level of ability for two groups taking two forms of a test.

Computing and Facilitating Tables, Nomographs and Work Sheets or Job Descriptions. The following devices for facilitating computations were suggested: (a) job description of Wherry-Doolittle test selection method (159); (b) job description and work sheet for computing Pearson r by "difference" (diagonal) method (187); (c) work sheet for applying Adkins-Toops simplified formulas for item-selection (238); (d) job description and work sheet for factor analysis involving thirty-five or fewer variables (124); (e) work sheet for correcting correlations for restriction on one variable (253); (f) item analysis against median split on total test score (Richardson's Nomograph) (80); (g) expectancy figures based on validity coefficients for various Army tests (232); (h) table for changing ranks in groups smaller than 100 to equivalent rank in a group of 100 (193); (i) values of ΣX, ΣX^2, ΣXY, ΣY, and ΣY^2 for values of N from one to twenty for each cell of a 13 x 13 scatterplot (188); (j) four-place table of $\frac{pq}{z}$ for three-place values of p or q (141); (k) facilitating tables for obtaining standard *AGCT* scores from number of attempted items and number of right answers (33); (l) probable error of median for certain values of Q and N (28); (m) value of $1-r^2$, $\sqrt{1-r^2}$, and $\frac{r}{\sqrt{1-r^2}}$ for various values of r (2); and (n) value of $\frac{1}{\sqrt{1-r^2}}$ and $\frac{2}{\sqrt{1-r^2}}$ for values of r (11).

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CHAPTER V

Research For or By the Armed Forces

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Selection Research on Mental Adjustment

RESEARCH in the field of mental adjustment in the Armed Forces consisted of (a) selection studies which used tests mainly of the paper-and-pencil variety to appraise the emotional stability of servicemen and (b) studies which attempted to make the same assessment on the basis of psychiatric interviews, situation tests, and other screening procedures.

The use of the *Rorschach* in evaluating military personnel was discussed by Linn (134) in a study in which *Rorschach* records obtained from a group of enlisted men assigned to a hospital were compared with performance ratings a year later after eight months of overseas duty. Responses given by well-adjusted soldiers were markedly different in many respects from norms based on well-adjusted civilians. The hypothesis was advanced that personality constriction and regression were produced by military indoctrination.

A group of papers on the construction, standardization, application, and results of research on the *Cornell Indices* and the *Cornell Word Form*, included a report by Mittlemann and Brodman (159) suggesting that the *Cornell Service Index*, *Selectee Index*, and *Word Form* were designed to differentiate quantitatively individuals with personality and psychosomatic disorders and to facilitate qualitative diagnosis of these disorders. A report by Weider and Wechsler (261) discussed the results of the application of the *Cornell Indices* and *Word Form*, the criteria of significant answers, and validity data. Wolff (266) indicated that with their basis of clinical experience and psychological and psychiatric principles the Cornell instruments might be used at induction stations, clinics, neuropsychiatric wards, and medical and surgical wards in hospitals, or in industry, veteran placement, research, and hospitals and clinics in civilian work. Harris (78) discussed the use of the *Cornell Selectee Index* as an aid and timesaver in the psychiatric diagnosis of naval personnel.

The *Personal Inventory* was discussed by Shipley and Graham (199) who presented a report and complete bibliography of the work on that and other tests of emotional stability. Satter (188) reported a study in which the results of the *Personal Inventory* were compared with success and failure in parachute school. Satter (187) also discussed the inability of the *Personal Inventory*, the *Otis Tests of Mental Ability*, the *Two-Hand Coordination*, several other tests, and psychiatrists' evaluations to predict officers' ratings of enlisted men in the submarine service. Shipley, Gray, and Newbert (200) found that the *Personal Inventory* differentiated between discharges from the Navy and men still active in the service after

Test, Form E-2; by Gulliksen (72) on the preparation of *Form 1* of the *Navy Officer Qualification Test* showing that the revised test had a wide range of difficulty and a satisfactory reliability; by Frederiksen (61) on the preparation of norms for the *Officer Qualification Test, Form 1;* by Gulliksen (71) on the preparation of norms for women on the *Officer Qualification Test, Form 1;* by Peterson (172) who gave a statistical evaluation of the *Navy Officer Qualification Test, Forms 2* and *3;* and by Frederiksen (60) who discussed the preparation of a spatial relations test, consisting of multiple-choice items concerning the rotation of solid forms, for selecting radar officers. Conrad and Lannholm (215) described the prediction of success in Primary Officer Training School and Maucker (215) described such prediction in Advanced Officer Training School.

Research in the Selection of Enlisted Personnel

The selection of enlisted men in the Navy was discussed in a group of studies. Odell (215) gave an account of the growth and development of the selection, qualification, and classification programs. Bond and Miller (215) described the development of the *Basic Test Battery*. The Staff of the Bureau of Naval Personnel (219) presented studies on item analyses, time limits, reliabilities, norm development, validity, intercorrelations, and factor analyses of the *Basic Test Battery*. The Staff of the Bureau (221) also discussed the validity of *Form 1* of the *Basic Test Battery* for selection for two types of elementary training schools. Bloom and Brundage (215) described the prediction of success in elementary enlisted schools. Curtis (215) described prediction in the advanced schools. Satter (187) found that there was no relationship between the scores on the *Otis Higher Examination*, the *Personal Inventory*, and the *Two-Hand Coordination Test* and officers' ratings of submarine crewmen on the job. Graham, Mote, and Berry (68) found that the same battery predicted "tank escape" performance failures considerably better than chance for submarine crewmen. Miller (157) reported a study on the choice of a test battery for selection of LCVP coxswains thru the use of the Wherry-Doolittle test selection method. Miller (156) also described reliability studies of six apparatus tests used with the Navy *Basic Battery* for the selection of LCVP coxswains, and in another study (154) reported that the Navy finally chose a hand dynamometer and a pegboard test from this group of mechanical tests on the basis of correlations with ratings on boat handling.

Research in Selection of Enlisted Personnel for Particular Jobs

Studies concerning the selection of fire controlmen and radar operators included studies of vision such as the one by Adams, Fowler, and Imus (3) which discussed the relationship between visual acuity and acuity of stereoscopic vision. Adams and others (4) found that the *Ortho Rater Tests* were sufficiently reliable as testing devices in the selection of candidates for training as fire controlmen and range finder operators. The interrelationships among seven tests of stereoscopic acuity and the relationship between two tests of visual acuity and two tests of Phorias were pointed out by Fowler, Imus, and Mote (56). The battery used in the selection of fire controlmen, range finders, and radar operators was discussed by Beier and others (21). Imus (88) presented the directions, procedures, tests, and equipment used in the selection and classification of fire controlmen. The final report on the Selection and Training of Radar Operators was made by Lindsley (117).

The Staff of the Bureau of Naval Personnel (222) described the construction of selection and achievement examinations and the conduct of technical personnel research designed to facilitate the selection and training of personnel in the maintenance and repair of electronic equipment. The predictive efficiency of the Navy Basic Test Battery at gunner's mates school was discussed by the staff of the Bureau of Naval Personnel (226).

Methods of selecting naval gun and engineering crews were discussed in a complete summary and bibliography of the Gunnery Project of the Applied Psychology Panel by Viteles, Gorsuch, and Wickens (242). Rogers, Viteles, and Voss (180) presented similar material for the Applied Psychology Panel Engineering crew project.

McQuitty (139) described the personnel selection program at an Engineering Replacement Training Center which was continuous, being coordinated with the training program, and was based upon the *AGCT* score, formal education, and first and second best civilian occupations. Selection for specialists' courses was on the basis of interest, success in a specialty, related hobbies, educational background, and aptitudes.

The work on the selection and training of night lookouts, including a discussion of validation of old night-vision tests, of the measurement of the performance of night lookouts at sea, and of an analysis of the night lookout's job, was summarized by Wedell (259). In a study of hearing in searchlight and other personnel requiring exceptionally good hearing, Clarke (31) reported that audiometers were unsuited for mass testing of acuity of hearing and suggested that gramophone records with words of varying intensities be employed. The study reported that only 40 percent of the 100 soldiers trained as listeners or spotters appeared to have, for both ears, hearing superior to three decibels loss. The best combination of tests for selecting Army weather observer students was reported by Cleveland, Faubion, and Harrell (32) to be a mental alertness test, a physics achievement test, and a meteorological achievement test.

Kurtz, Seashore, and Willits (107, 105) presented a discussion of the Code Receiving Tests developed by the Applied Psychology Panel.

Reid (178) reported that in aptitude tests for drivers in the Third Armored Division, the greatest number of failures occurred for glare blindness, defective acuity, and depth perception. A yarn test for color vision, a field of vision test, and tests of depth perception, glare, balance, stability, reaction time, and visual acuity were given to 10,000 prospective heavy-truck drivers in this study. The selection and training of cargo handling teams for combat-laden vessels was discussed by Ruch (185).

Selection tests and causes for rejection were described by Thomas (224) in a report on the selection of parachutists.

A report on the construction of various performance tests, group and individual, and of checklists for objective observation in the Teacher Training Department of the Armored Force School, Fort Knox, was presented by Siro (202).

Research on Classification and Aptitude Tests

Research in classification in the services included studies such as those McCain and Schneidler (135) discussed concerning the classification and selection of enlisted personnel. Eurich and McCain (50) also described the initial classification in which each recruit was given the general classification, reading, arithmetic reasoning, mechanical aptitude, clerical and mechanical knowledge tests, an interview, and then a recommendation for two possible jobs. The specifications for the construction of a general classification test, a reading test and a test of arithmetical reasoning were outlined by Frederiksen (62). The selection of items and a comparison of the selected items with those previously used for the *General Classification Test, Form 2,* and for the tests of reading and arithmetic was described by Satter (189). Wrenn (270) included in his description of Navy personnel procedures the nature of the classification interview and the training of interviewers. The derivation of national norms for the Fleet Edition of the *General Classification Test* was described by Peterson (171) who concluded from the data collected that the *GCT* (x-l-s) served satisfactorily as a self-administering test and constituted a parallel form of the *GCT, Form 1.* He (170) also reported on a factor analysis of the new *Navy Basic Classification Test Battery.* A statistical evaluation of the *Basic Classification Test Battery, Form 1,* led Conrad (35) to the conclusion that the battery competently fulfils the essential requirements.

Procedures and tests used to select men for assignment to fill the balance crews for newly commissioned destroyers on the Pacific Coast were discussed by Levin (111). The work of the Classification Section of the Armored Force Replacement Training Center described by Wittman (264) included material on the psychological, clerical, and mechanical-aptitude testing; on occupational interviews, testing and classification; on assignment to different military duties; on the selection of officer training candidates; on the liaison relationships with regular training companies; on the record keeping and planning of activity flow; and on research and selection of men for the Special Training Unit which handles and studies physical, mental, and psychological problems. Malone (142) described the Army Classification system, the use of the *AGCT*, the *Mechanical Aptitude Test,* and the *Radio Operators Aptitude Test*. An activity preference test furnishing a number of scores corresponding to clusters of functionally related activities was reported by Kelley (100) who outlined the steps leading to its development. The selection of personnel with superior vision for the crew of the *USS New Jersey* was described by Verplanck (231) in a study using an NDRC Adoptometer Model II.

Research on aptitude tests for the Navy was reported by Frederiksen (63) who described a study made on an experimental battery of aptitude tests as predictors of service-school grades for inclusion in the *Basic Classification Test Battery;* by Conrad (36) who presented the research and developmental history of the Navy's aptitude testing program; by Conrad (34) who also discussed the basic statistical facts concerning individual items of the *Navy Aptitude Tests* and interpreted these facts with reference to various problems; by Stuit and Feder (215) who described the development of special aptitude tests by the Bureau of Naval Personnel; by Gulliksen, Conrad, and Frederiksen (75) who confirmed an earlier conclusion, by studying the averages, standard deviations, and intercorrelations of the Navy aptitude tests, that variations in procedure from one station to another constitute a serious problem; by Gulliksen (73) who compared the selection of test items for a mechanical comprehension test by an item analysis based on an external criterion and by the technic of item-total correlation and also (74) presented minor modifications which could be made in a short time to the *Navy Mechanical Aptitude Test, Form T*, and made suggestions for a more thoro revision of the test.

Validation research was presented by Frederiksen (64, 63) in a discussion of the validities of aptitude tests at various schools; by Crawford and Burnham (45) in a report on the results of the educational aptitude testing of V-12 students in which it was found that aptitude tests proved to be effective predictors of academic work measured by objective achievement tests; and by Anderson and others (10) in a paper on the Oscilloscope Operator tests. Prediction of ability was discussed by Kurtz (104) in relation to code learning. Prediction of success in Electricians' Mates School was presented by Conrad and Satter (37) in a discussion of the use of test scores and quality classification ratings. A report was given by Smith and Voss (206) on a study of the effectiveness of the classification procedures for officers of the Amphibious Training Command. Smith and others (207) also reported on the effectiveness of classification data in predicting billet performance in training in the Amphibious Force. Prediction of success in service school from the order of assignment was discussed by Satter and Conrad (190). A study presented by Wedell (260) reported on the prediction of the performance of night lookouts.

Procedures used in a job analysis of the tasks performed at gun stations were enumerated by Viteles and Smith (243). The final report and summary of work in job analysis qualification and placement of personnel in the Amphibious Force was presented by Smith (205).

A selectometer for weighting the qualities on which interviewers rate men was discussed by Keislar (93) and by Campbell (30) who made a final report on research and development of classification aids. Another classification aid, the point-score method for evaluating Naval personnel was presented by Levin (112). Viteles (233) presented an interviewer's recommendation chart which shows in visual form the billets aboard ship for which an individual with given qualifications is most adapted. The personal preference technic, which employs the opinions of co-workers or students who have had adequate time to observe their fellows, was discussed by Wiggin and Bartlett (263) as a possible supplement to instructor's grades.

Research on Training

In an article on military training and learning theory, Wolfle (267) indicated that help was given to military specialists in World War II by psychologists who applied such principles of learning as distribution of practice, active participation, variation of material, accurate records of progress, knowledge of results, and systematic lesson plans. Applications of these theories appeared in some of the work discussed below.

Gunnery-training research included such studies as the ones discussed by Viteles *et al* (235, 245, 246, 249, 251, 252, 253), outlining training aids, lesson plans, and courses of instruction for a four-day course in 20 mm and 40 mm gunnery; by Viteles (234) who investigated the scoring characteristics of the Machine Gun Trainer, Mark 1; by Smith *et al* (208) presenting a memorandum on gunnery teaching; by Covner and Viteles (40) presenting instruction in engineering, damage control, and gunnery at the CVE Precommissioning School; and by Viteles, Gorsuch, and Wickens (241) describing the standardized four-day courses using unit lesson plans for a gunnery-training program, and the study of synthetic training devices. Range-estimation studies included Wickens, Gorsuch, and Viteles' (262) account of lesson plans for instruction on the mirror Range Estimation Trainer Device 5C-4; Voss and Wickens' (255) comparison of free and stadiametric estimation of opening range; Horowitz and Kappauf's (84) description of the accuracy of unaided visual range estimation for aerial targets at ranges between 1500 and 8000 yards; Viteles *et al*'s (248) analysis of the results obtained in training men in range estimation on the firing line; and by Rogers' (181) evaluation of methods of training in estimating a fixed opening range. Hoffman and Mead (82) discussed the performance of Anti-Aircraft Artillery personnel on a complex task of four-hours duration. Research in the training of engineers was discussed by Rogers, Viteles, and Voss (179, 180); and by Viteles, Gorsuch, and Watters (240) who discussed the improvement of a training program for newly organized crews for destroyers and for auxiliary ships. Masoner and Watters (149) presented an instructor's manual which served as a guide in the administration of special engineering courses. A manual for training balance crew engineers for attack transport vessels was described by Covner, Gorsuch, and Viteles (41). Viteles and Gorsuch (236) prepared a memorandum on effective teaching methods for engineering instructors. A group of studies concerned with progressive engineering were reported by Viteles and Gorsuch (237, 238) who presented lesson plan outlines for Stages I and II of the instruction; by Organist *et al* (167), who prepared an instructor's manual for Stage II and who presented outlines for instructions in Stage III (165); and by Organist and Willis (166) describing the organization and instruction for Stage III. Covner *et al* (44) prepared an instructor's manual for presenting information on the distilling plant to engineering personnel.

The training of fire controlmen and range finder operators was presented by Beier *et al* (20) in the form of a series of lesson plans. The influence of visual tasks in the training course of fire controlmen upon their visual proficiency was discussed by Adams, Beier, and Imus (2). Covner, Gorsuch, and Viteles (42) presented a manual for instructors with a detailed step-by-step procedure for operation of fireroom equipment on destroyer escort vessels.

The training of radar operators was reported on by Lindsley *et al* (132), who discussed the use of the Philco trainer for A-scan oscilloscope operators; and by Lindsley *et al*, in a series of articles (120, 128, 133), describing and presenting recommendations and generalizations for the use of the PPI flash-reading and tracking trainers in training Navy search-radar operators. Lindsley (119) also gave an account of the results of a study determining the effectiveness of the course of training SCR-270-71 radar operators. The effectiveness of the Foxboro Trainer in training oscilloscope operators to track by means of pip-matching was evaluated by Lindsley and others (129), who also made recommendations for its use (127). A study of the SCR-584 basic trainer as a device for teaching range tracking was presented by Lindsley *et al* (130) and by Anderson *et al* (9). The Lufts Tracking Trainer was described by Hudson and Searle (85). The results of developmental work done on the design and construction of a director tracking trainer and experiments to determine the effects of various fatiguing circumstances on performance were summarized by Mead (151). Kappauf (92) reported on phototube scoring devices for tracking trainers. An experimental investigation involving a comparison between tracking to a fixed hairline and tracking to a rotating hairline was presented by Lindsley *et al* (124). Experiments in training radar operators in visual code reception were discussed by Anderson *et al* (8) and by Lindsley *et al* (125). The use of radar scope movies for briefing and reconnaissance purposes was evaluated by Lindsley (122). A study of performance was reported by Lindsley and others (131) concerning the reactions of radar operators under speed stress. He also described the factors determining the accuracy of reading oscilloscope code in a study (126) designed to find the speed, width, amplitude, dot-to-dash ratio, and letter-code cycles at which code can most accurately be read.

An extensive group of studies concerning the training of telephone talkers was discussed by Black and Mason (24); by Snidecor, Mallory, and Hearsey (210) in relation to the use of mass drill, continuous prompting, instruction by skilled men, dramatic recording, criticism, and discussion as methods of training telephone talkers for increased intelligibility; by Hibbitt and Mallory (81) in relation to an experimental investigation of a course for telephone talkers; by Curtis (46) in relation to increasing the intelligibility of voice communication by training in voice technic and (47) in relation to the use of noise in a training program; by Abrams and others discussing the factors determining the intelligibility of speech in noise; and by Mason (146) concerning the effects of training on articulation. Mason and others (147) reported on the indoctrination of aircrewmen in voice communication at altitude and (148) on the training studies in voice communication. Studies of the effect of pitch on the intelligibility of voice communication were discussed by Mason (145). The relationship between loudness and intelligibility of airplane interphone communication was pointed out by both Curtis (48) and Talley *et al* (218). Reports on the analyses of mistakes made in word intelligibility tests over the T-17 microphone (144) and on the phonetic characteristics of words as related to their intelligibility in aircraft type noise (143) were made by Mason. Intelligibility in relation to various methods of holding the T-17 microphone for communication in noise was discussed in a report of the Psychological Corporation (177). Talley, Curtis, and Haagen (217) reported on a related study on microphone position in voice communication. Snidecor (209) dealt with a preliminary study of the ability of rated men to judge speaking performance. Anonymous articles gave accounts of a study in training Classification Petty Officers to select telephone talkers (14) and of a speech interview for the selection of telephone talkers (13). The final report in summary of the work on the selection and training of telephone talkers was made by Mallory and Temple (141). An account of the technics and procedures used by the Voice Communication Laboratory was presented by Haagen (76). The final summary of work on voice communication was given by Black (23).

Reports on training studies in radio code work include a summary of research in Radio Code Project N-107 by Kurtz and Seashore (106) and in Project SC-88 by Keller (95); a comparison of training methods at two levels of code learning by Keller, Estes, and Murphy (98); reports by Keller and Estes (96, 97) on the effectiveness of different types of practice in code learning and by Keller (94) on the code voice method of teaching; a comparative study of three methods of teaching code in the early weeks of the course by Seashore and others (195); and a discussion of the standardization of code speed by Kurtz, Seashore, Stuntz, and Willits (108). The development of a graduation and rating test for Class A radio schools was discussed by the staff of the Psychological Corporation (176). A group of four studies concerning methods to be used in code classes included Seashore and others' (197) discussion of variation of activities to prevent monotony in code classics; their (196) report on the effect of introducing sending code early in the course upon learning to receive; Seashore and Stuntz' (194) manual of activities for reducing monotony in code schools; and their (193) experimental study of the training of radio operators to copy code thru interference. Seashore and Kurtz (192) presented an analysis of the errors made in copying code.

A miscellaneous group of training studies included a report by Ruch and others (186) outlining training procedures and lectures on winch operations and presenting a rating form for grading trainees on electric winch operation; a critical evaluation by Shuttleworth (201) of the Army Specialized Training Program with reference to selection standards and the method of "block training"; a discussion by Layman and Boguslavsky (110) of the relationship between ability and achievement in the Army Specialized Training Program which pointed out that "neither secondary schools nor colleges were sufficiently challenging to induce maximum relationship between ability and academic achievement in many individual instances"; a presentation by Carstater (215) of the Bureau of Naval Personnel program for officer training and one by Batchelder (215) for enlisted personnel. Feder (53) reported standardization of instruction in several Navy schools concerned with elementary electronics training thru the construction of an achievement test and the standardizing of procedures on the basis of test results.

Training Devices

Discussions of studies concerning training devices included Exton's (52), Noel's (163), and Stott's (213) accounts of the use of audio-visual aids in expediting the Navy training program. Wattles (258) presented the results of the teaching of gunnery with aids such as flash cards, films, rating sheets, lesson plans, and observation record forms for evaluating the instructor. Ullman (227) described the procedures of several night-vision training devices. Lanier (109) explained a night lookout trainer for use aboard ship. Dresser (49) examined the use of slide films in the Navy training program. Witty and Goldberg (265) discussed the use of flash cards, training films, film strips, picture portfolios, bulletin boards, posters, cartoons, maps, diagrams, charts, and other visual aids in special training units in the Army. An anonymous article (90) described the shortcuts in learning skills, ways to speed training, study books, manuals and lessons, and other aids to military training. Thomas (225) reported on the use of animated cartoons in training and indoctrination in the Army. A discussion of ship models in classroom instruction and other training aids was presented by Viteles and Gorsuch (239).

Viteles and others (250) presented a discussion of the psychological principles involved in the design and operation of synthetic trainers with particular reference to anti-aircraft gunnery. Viteles and others (247) also described an investigation of the Range Estimation Trainer Device 5C-4 as a method of teaching range estimation. The use, characteristics, advantages, and disadvantages of all the synthetic trainers used by the Applied Psychology Panel projects were compared with training on real equipment by Wolfle (268).

Morale Research

Discussions concerned with the factors affecting morale included a report by Madigan (140) which emphasized the difficulties in army adjustment and the ways in which morale problems might be countered; one by Prattis (173) concerning the morale of the Negro in the Armed Services under the treatment received; and one by Evans (51) and one by O'Gara (164) pointing out some factors affecting military morale. Blain (25) discussed the war neuroses of merchant seamen and the personal and morale factors involved in their etiology and prevention. Homans (83) reported on the problems in morale and leadership on small warships. Woods (269) discussed the morale factors of naval noncombatants; Baganz, Mearin, and Woods (15) presented an account of the mental mechanisms and morale factors of Naval recruits in training. An anonymous writer (89) summarized the points mentioned by soldiers as the features of army life most closely related to morale. A consideration of the development of rumors in the service and the ways of checking them was presented by Kelly and Rossman (101).

Discussions of the factors which build morale included a presentation by Bassan (17) of factors found valuable in maintaining morale on a small combat ship; an account by Smith (204) of the personnel policy of the Navy and its relation to morale; a report concerning the problems of procurement, training, and morale among members of the Women's Reserve of the U. S. Coast Guard by Stratton and Springer (214); a description by Rose (182) of the bases and weaknesses of American military morale in World War II; considerations by Schroeder (191) and by Kreinheder (103) of the orientation program in the Army and the qualities of good orientation officers; an anonymous article (153) concerning planned orientation for combat, orientation objectives, and the execution of the orientation course; a presentation by Brosin (28) of a program for utilizing the marginally unfit in the Armed forces and an analysis of the basic principles involved in morale improvement; a description of an analysis made of the morale of American occupation troops before and after the end of World War II and means of improving military morale by Warner (256); and a report by Rottersman (183), based on the analysis of 20,000 selectee questionnaires regarding complaints, on morale as a factor in complaint reduction.

Civilian research in morale included Allport and Schmeidler's history (6) of a clearing house to aid psychologists in problems of morale. Shils (198) discussed the effect of governmental investigation on attitudes and morale. Appel and Hilger (12) presented a morale and preventive-psychiatry program in the Army. Osborn (168) summarized the services of the Morale Branch of the War Department as they affected the recreation, welfare, and morale of the American soldier.

Leadership Studies

A suggestion was made by Miller (158) that leadership could be taught by actual training under officers who are themselves good leaders and by experiencing leadership and its problems. A discussion by Metsker (152) included material on the mental characteristics of military leadership from the standpoints of selecting and training leaders. Mayberry (150) described an interview rating scale and technics employed in evaluating leadership qualities of officer candidates. McNassor (138) and Bavelas (18) discussed the training of leaders, and MacKechnie (136) reported on the development of leadership in small unit commanders. An outline syllabus, used as an aid in the Academy's first course on the psychology of military leadership, was presented by the U. S. Military Academy at West Point (228). Intangible factors in combat, including teamwork and leadership were considered by McLain (137). Garrett and Ligon (66) in a report on combat leadership concluded that unless leadership is defined in some way which permits direct measurement of specific qualities, research on predictive items is likely to be useless. Ligon (116) discussed the problems of choosing efficient officer candidates, reports from combat area, and interviews with ex-combat officers concerning the characteristics of good combat leadership. A study of traits most frequently mentioned for a good officer and for distinguishing a good officer from a good enlisted man was reported by Heath and Gregory (80). Ageton (5) presented a discussion and bibliography on military leadership and training methods. The development of a manual for instructors of leadership courses in Officers' Training School was presented by the Staff of the Bureau of Naval Personnel (29). The OSS Staff (229) gave an account of the measurement of leadership in life situation tests such as the *Mined Road*, *Getting Past the Sentry*, *The Blown Bridge*, and *Killing the Mayor*, where candidates were assigned leadership and expected to lead a group of men.

Proficiency and Achievement

Problems in the measurement of achievement in Naval Training Programs, the types of tests developed and the outcomes of the Achievement Examination Program were described by the Staff of the Bureau of Naval Personnel (220). A group of reports on achievement included Ryan's (215) and Feder's (54) discussions of the services provided to Navy Training thru achievement examinations; Porter and Harsh's (215) presentation of achievement examinations for elementary enlisted schools; Feder and Lawrence's (215) account of the measurement of achievement in the Radio Technician Training Program; and Cruikshank and Darling's (215) description of the *Advancement in Rating Examination* developed

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CHAPTER VI

Wartime Research in Psycho-Acoustics

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THE PRESSING demand for effective voice communication during the war stimulated widespread research in psycho-acoustics—the application of psychological methods to problems of acoustics, speech, and hearing. Existing communication equipment and technics had to be tested; new equipment and technics had to be designed. Typical wartime noises had to be measured and studied, their effects evaluated, and some of them combatted. Human factors in communication had to be determined, utilized, and allowed for. Some of the studies directed toward these problems are mentioned in this chapter.

Summaries of the extensive research on psycho-acoustics of the Applied Psychology Panel are contained in the book, *Human Factors in Military Efficiency—Training and Equipment*, by Wolfle and others (135) and in two reports by Black (18), and by Mallory and Temple (87). The work of the Psycho-Acoustic and Electro-Acoustic Laboratories, Harvard University has been summarized by Miller, Wiener, and Stevens (97). This book includes references to relevant work performed at other laboratories and considerable background information.

Voice Communication

Basic to the investigation of speech material, communication personnel, and communication equipment was the method of "articulation tests" (30, 31, 59, 60, 61, 111, 126). This was a method of testing communication systems by determining how well they serve to transmit speech. Carefully chosen speech items were employed; the proportion of items correctly received provided an indication of the relative effectiveness of the system. For any devices under consideration, as, for example, microphones, articulation tests could be used to indicate the relative effectiveness of different possibilities: carbon microphones, dynamic microphones, and magnetic microphones. Alternatives to the formal articulation test were abbreviated testing methods (31), subjective appraisal of intelligibility (6, 31), and threshold methods for evaluating intelligibility (31).

Speech Material

The type of speech material used was found to be an important factor in intelligibility. Analyses were made of the phonetic characteristics of words as related to their intelligibility (1, 3, 6, 18, 89, 90). Recordings of messages made in combat situations were analyzed to provide information about common errors and failures of communication (7, 18). Intelligibility involves not only the physical characteristics of speech material (acoustics spectra) but also such characteristics as the average number of sounds per word, the relation of a word to other words in the language, and apperceptive variables (97). On the basis of such considerations, there were tested and constructed highly intelligible vocabularies, phonetic alphabets, standard forms of command, and lists of call signals and telephone directory names. Various procedures for the pronunciation of numerals were also tested (1, 2, 3, 5).

Distortion

Distortion and interference are also factors in intelligibility. Experiments on amplitude distortion were performed with nonlinear circuits which either clipped the peaks or the center of the signal, or rectified the signal. The effects of each type of distortion on intelligibility were determined by articulation tests, and various measures of distortion were compared for their relation to the impairment of intelligibility (78). The effects of adding noise, both before and after distortion, were studied. Peak clipping (58, 73, 75, 76, 78, 79, 81, 85) was found to improve the intelligibility of a signal if measurement was in terms of peak voltages. Such peak clipping may be used to advantage in hearing aids to protect the ear at high intensity levels, in AM radio transmission to allow continuous 100 percent modulation, and in radio telephony to improve intelligibility when static is present. Center clipping and rectification, on the other hand, were found to be detrimental to intelligibility.

The effects of frequency distortion on intelligibility were investigated with the use of low-frequency cut-off (43, 125), gradual "tilted" cut-offs (58), and band-pass filters (39, 40). Various levels and spectra of masking noise were used. Results showed that an adequate speech-to-noise ratio should be provided over as wide a frequency range as possible. For ideal speech transmission, the frequency range should extend from about 200 to 7000 cps, and the signal-to-noise ratio at each frequency should be 25 db or more. Combined frequency and amplitude distortion was studied with speech material that was both "tilted" (i.e., put thru a system with an oblique response characteristic having a regular gain per octave) and peak clipped (58).

The quality of speech was found to change at high altitudes (71, 80, 113). Attempts to improve the intelligibility of speech at high altitude thru deliberate frequency distortion gave little success (96). Modifications of equipment resulted in improved performance (83).

Interference

Interference was a major problem of military communication, and an extensive range of signals and noises was investigated to determine what factors contribute to their effectiveness for masking (39, 48, 62, 93, 95, 112, 123, 125, 128). The important dimensions of interference are its intensity, frequency, spectrum, temporal continuity, and annoyance value. Noise was found to mask best when it is uninterrupted and when it has a broad spectrum with a signal-to-noise ratio that is constant at all frequencies. Greater annoyance is caused by interrupted and high-frequency interference. Pure tones do not mask speech effectively, but continuous tones of low fundamental and rich in harmonics mask almost as well as noise, and they are more annoying. Speech can be used to mask other speech, but its spectrum and not its meaning is the chief factor in masking.

The effect of interference was investigated also in the case of radio range signals (50), and radar signals (53).

Selecting and Training Personnel

Since an effective communication system requires good talkers and listeners, research was conducted in selection and training of personnel. Studies were made on the rating of talkers (6, 15, 100, 109, 110, 120, 121). Voice factors found to be closely related to intelligibility were loudness (21, 22), and intensity control (100), and precise articulation (92). Factors showing a slight relation to intelligibility were pitch (91), voice spectrum (6), rate of speaking (18), telephone experience, education, listening ability, and memory span (100). General American dialect was found to be slightly more intelligible than Southern or Eastern (100).

It was easier to test listeners than talkers, because standardized phonographic tests could be given to many listeners at once (24, 69, 107). Articulation tests given under relatively quiet conditions were found not to show who will listen well in noise (110). Noise generators were therefore designed for testing and training programs (11, 12, 48, 101, 127). Experiments suggested the existence of an ability to listen in noise which is independent of distortion due to particular equipment of the spectrum of the interfering noise, and of the type and mode of presentation of the speech material (69). Slight relation was found between listening ability and the following measures (69): code ability, intelligence as measured by the *GCT*, auditory memory span (4), and speaking ability. Listening ability was found to be somewhat related to region of residence (18). Experiments were also made to determine the nature and extent of individual differences in the detection of small changes in noise; tests were constructed for discrimination of pitch and loudness of noises (68). These have not yet been used in studying listening ability.

Rapid and extensive improvement of performance was obtained with training of both talkers and listeners (18, 110). Several training programs were devised and tested (5, 16, 23, 24, 64, 88, 92, 99, 122); manuals and syllabi were prepared (8, 9, 10, 14, 99); special training equipment was designed and used (11, 98). The improvement found was attributed to several factors; training in voice technic (23), training in the use of communication equipment (6, 13, 32, 47, 104, 110, 129), and training in the identification of words that are partially masked by noise or distorted by characteristics of the equipment used (24, 110).

Communication Equipment

Along with speech material and communication personnel, communication equipment was studied in the over-all program of bettering military communication. The testing methods used by the Harvard Psycho-Acoustic and Electro-Acoustic Laboratories and the results they obtained are reviewed in a technical summary report (97).

Microphones were tested with the human voice and with artificial "voices" (17). The properties of earphones were tested by utilizing the responses of listeners; by measuring sound pressures at the ear canal with a probe tube (102); and by the use of artificial "ears" (17, 132). The pressure distribution in the auditory canal was also obtained in a progressive sound field by use of the probe-tube technic (133). Earphone cushions, earphone sockets and headsets (36, 37, 41, 57, 116), and masks (74) were tested for their effects on communication. Measurement was made of physiological noise generated under earphone cushions (94). The characteristics of microphones (56) and noise shields (35, 131), amplifiers (80), radio link (21), and receivers (20, 33, 86) were investigated. Studies were made of radio equipment, interphone equipment (43, 46, 71, 80, 83), sound-powered equipment (38, 54, 134), and radio-range equipment (55).

Effects of Noise on Psychomotor Efficiency

One of the first military projects of the Psycho-Acoustic Laboratory was to study the effects on psychomotor efficiency of intense noise and vibration (123, 128). A battery of psychological, psychomotor, and physiological tests was developed and used to evaluate the effects of noise on a wide variety of tasks. In some of the experiments subjects were exposed to 115 db of airplane noise for seven-hour work days over a one-month period. The subjects reported the noise to be disagreeable and tiring, but their performance was largely unimpaired by it. They had temporary hearing losses following exposure to noise—losses whose extent and duration depended upon the over-all intensity of the noise, its spectrum, and length of exposure. Other reports give fuller information in intense stimulation as the cause of temporary deafness, injury of the inner ear, and other physiological effects (25, 26). In one of the psychomotor tests the subjects' coordinated serial reaction time showed an increase of 5 percent in the noise. This was actually the greatest effect of acoustic stress shown by any of the psychomotor tests, and the validity of this result is open to question. No other test showed significant decrements of performance due to noise. Indeterminate effects of noise were found in the following tests: muscular tension, metabolism, breathing, speed of accommodation, saccadic movements, body sway, hand steadiness, reversible perspective, and dark adaptation. No effects of noise were found in these tests: coordinated serial pursuit, serial disjunctive reaction time, fast-speed pursuit rotor, card sorting, coding test, and judgment of distance. Vibration caused a considerable reduction in visual acuity in every subject. An extensive investigation was made of sound as a military weapon (19). Direct use of sound as a weapon was found to be impractical because it required too great an expenditure of energy.

Noise Measurement

Investigation of the effects of noise on communication and psychomotor efficiency required measurement of noise intensities and spectra. The problems and methods which this entailed have been reviewed by Miller, Wiener, and Stevens (97).

Combatting Noise

Noise reduction, sound insulation, and aural protective devices were used to lessen impairment of communications and to reduce annoyance (97). Airplane noise was attenuated by sound-proofing materials (29). Sound insulation was accomplished by proper design of earphone cushions, sockets, and headsets (34, 42, 45, 49, 57, 114, 116, 118) and by development of special insert tips for use with miniature earphones (117). Protection against noise and gun blasts was afforded by special earplugs (70, 77, 115). Reception of speech slightly above normal levels was not impaired by the use of these earplugs; in noise, audibility of speech was, in some instances, improved by their use (72).

Hearing Loss and Hearing Aids

Several tests were developed for the direct measurement of hearing loss for speech (67, 105, 106, 108). These tests employ recordings of selected words and sentences, the loss being measured from standards set by normal subjects. The use of such test material transmitted thru filters may allow differential diagnosis of uniform losses and high-frequency hearing losses for speech (65). The tolerance of normal and hard-of-hearing subjects for intense sounds, both pure tones and speech, was determined. Thresholds of discomfort, of tickle, and of pain were measured (119).

Commercial hearing aids were evaluated on the basis of electro-acoustic and psycho-acoustic measurements (97, 102, 103). Studies of design objectives for hearing aids (27, 28, 66) indicated the desirability of these properties: uniform frequency response between 300 and 4000 cps, limitation of maximum acoustic output, an effective gain control with a range of at least 40 db, and no acoustic feedback or electrical feedback ("squeal").

Auditory Signals for Instrument Flying

The possibility of putting some airplane instrument indications in auditory form was investigated (51, 52). Auditory signals were devised which "sounded like the behavior of the airplane," and which did not interfere with reception of radio-range signals or voice communication. An "automatic annunciator" was developed to translate instrument indications automatically into spoken messages and to announce them to the pilot. The annunciator had a readily identifiable speech quality, and there was little difficulty in distinguishing between it and outside speech sources.

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